ELEMENTS OF CHEMISTRY,

AND

NATURAL HISTORY.

TO WHICH IS PREFIXED

THE PHILOSOPHY OF CHEMISTRY.

BY A. F. FOURCROY.

TRANSLATED FROM THE FOURTH AND LAST EDITION OF THE
ORIGINAL FRENCH WORK,
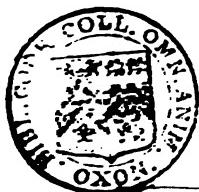
BY R. HERON.

IN FOUR VOLUMES.

VOL. I.

TO

Dr. B L A C K.

THIS tranflation of *Fourcroy's Elements of Chemiftry*, a work which has been honoured with his recommendation of it to the ftudents of Chemiftry, is refpectfully dedicated, by

His obedient,

And very humble Servant,

THE TRANSLATOR.

EDINBURGH,
Mar. 4. 1796.

¹

C O N T E N T S

OF THE

FIRST VOLUME.

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CONTENTS.

E R R A T A.

Page 460, line 8th, from top; *for* Fluate of Soda, *read* Fluate of Potash.
460, line 11th, *for* Fluate of Soda, *read* Fluate of Potash.

ADVERTISEMENT.

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THE general truths in any fcience are continually mul-
tiplied, as its perfection advances, and as its means of
inveftigation are improved. Such has been the fortune of
chemiftry. Its firft principles have been but lately afcertain-
ed: And it is already rich in corollaries, or general refults,
which embrace and combine all its parts. A fyftematic view
of thefe refults may be highly ufeful. During thefe laft twelve
years, I have conftantly endeavoured to arrange them into
fome fuch form. I have often, in my courfes of lectures,
given a fketch of the arrangement I had adopted : More par-
ticularly, in thofe lectures, with which I every year clofe my
courfe. When explaining the phænomena exhibited by the
known elaftic fluids in their evolution, their fixation, and
their influence upon all the operations of Art and Nature ; I
take occafion to review the fundamental principles of the
Science ; and give fuch an abftract of its whole materials, as
recalls to memory all the changes to which natural bodies are
liable, under the power of their reciprocal attractions. But,
in any attempt to combine together thefe capital truths, great
perfpicacity of difcernment is requifite, to enable us to felect
thofe more general facts, in which all the minuter ones are
be fo comprehended, that they may be deduced from them, as
fo many corollaries. Thofe more general facts muft like-
wife be expreffed with perfpicuity and precifion, without
ambiguity, without doubt, without loofenefs of language.
They muft not be too numerous, but yet fufficiently fo to
include every general fact of any importance. They muft
alfo be arranged in fuch a confecutive feries, and with a mu-

A   tual

tual connexion fo natural ; that they may exhibit all the ele-
ments of the fcience, and may fhew their reciprocal relations
and dependencies.

Thefe ideas have regulated my inveftigation of thofe
truths. I thought that they might ferve for the foun-
dations of a complete fyftem of chemiftry; which fhould
embrace fuch a number of principles, and thofe fo happily
applicable to every minuter phænomenon ; that it might
enable perfons already well acquainted with the fcience, to
recollect all that immenfe multitude of facts of which it is
compofed ; and might, at the fame time, explain to the begin-
ner in chemical ftudies, the nature of the courfe on which he
is entering.

It appeared to me, that I fhould beft accomplifh this
purpofe, by exhibiting a regular feries of propofitions,
allied to one another by general relations, and fo arran-
ged, that their mutual connexion might be eafily perceived.
This I call *The* PHILOSOPHY OF CHEMISTRY. All the pro-
pofitions contained in it, have been already printed under the
article AXIOMS, in the chemical department of the New En-
cyclopædia. For the ufe of the ftudent of chemiftry, I have
thought proper to publifh them alfo apart, and in a commo-
dious form.

The fuccefs of the firft edition of *The* PHILOSOPHY OF
CHEMISTRY, has encouraged me to reprint it. I have made
a few alterations, and fome fmall corrections, but hardly any
addition. The nature of the work is fuch, that it can be little
enlarged, until the fcience fhall be greatly augmented, and
enriched with important new difcoveries.

PHILOSOPHY

PHILOSOPHY OF CHEMISTRY.

ALL the obfervations and experiments of Chemiftry, may be reduced under the twelve following general heads.

I. The action of *Light*.

II. The action of *Caloric*.

III. The action of *air in Combuftion*.

IV. The nature and action of *Water*.

V. The nature and action of *Earths;* the formation of *Alkalis ;* and the parts which thefe bodies act in *combinations.*

VI. The nature and properties of *Combuftible Bodies.*

VII. The formation and decompofition of *Acids.*

VIII. The union of *Acids* with *Earths* and *Alkalis.*

IX. The oxidation and folution of *Metals.*

X. The nature and formation of *Vegetable Subftances.*

XI. The tranfition of *Vegetables* into the ftate of *Animal Matters ;* and the nature of *Animal Matters.*

XII. Laftly, the fpontaneous *decompofition of Vegetable and Animal Subftances.*

THESE twelve articles may be made the titles of fo many chapters ; under each of which, may be introduced all fuch particulars as have a more natural and direct connexion with it, than with any of the others ; and which fhall all together comprehend the whole fum of our Chemical Knowledge.

C H A P.

CHAPTER I.

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The ACTION of LIGHT.

I. LIGHT, whether it be emitted from the Sun and the Fixed Stars, or be naturally diffufed through all material fpace, has four different modes of action in refpect to the other bodies with which it comes into contact. It is either reflected wholly without decompofition from their furfaces, fo as to give the fenfation of *Whitenefs*, when it meets the eye: Or it is decompofed, and but partially reflected, exhibiting any of all the variety of colours, except *White* and *Black* : Or it is more or lefs entirely abforbed, fo as to afford to the eye, nothing but a *Black* fhade : Or it paffes through the bodies meeting it, with a greater or a fmaller deviation from its former direction towards the perpendicular; which conftitutes *Tranfparency*.

II. Paffing through tranfparent bodies, it is refracted in the direct ratio of their denfity, if they be incombuftible ; and the refraction increafes in the direct ratio of the increafe of the combuftibility of the body through which the light paffes. Hence did Newton conjecture the combuftibility of the diamond, and the exiftence of a combuftible principle in water.

III. Light fuffering refraction, is decompofed into feven different rays ; red, orange, yellow, green, blue, indigo, and violet. It has been fuppofed, that three of thefe colours are fimple; red, yellow, and blue ; but the other four, compounded, each of thofe two which appear on each fide, next to it in the refracted pencil of rays ; orange, of red and yellow ; green, of yellow and blue ; indigo, of blue and violet ; violet, of red and indigo. This opinion, however, has not been fatis-

The

factorily proved. The decompofition of light by the prifm, is a fort of analyfis of it.

IV. Light acts likewife *chemically* upon bodies, in proceffes of combination and decompofition. Bodies immerfed in light, differ in their character, from bodies kept remote from its contact; even when the other circumftances are equal. The former ufually become coloured, volatile, and inflammable; the latter exhibit properties oppofite to thefe.

V. By this chemical action of light, fome acids are decompofed, and various other falts undergo a change of nature; metallic oxides are in general reduced nearly to the metallic ftate; vegetables acquire colour, fapidity, and inflammability. Plants withdrawn from the impulfe of light, remain white and infipid; in confequence of which they are faid to be *etiolated.*

VI. Light feems to produce thefe effects, almoft folely by abftracting from bodies which have been burnt, that principle which they abforbed during the combuftion; and by thus reftoring to them that combuftibility which they had loft. It may be faid, that light *unburns* burnt bodies.

The *foregoing propofitions* may be *applied* to explain
    The colours of bodies;
    Tranfparency;
    Opacity;
    Brilliancy;
    Single or double refraction;
    Metallic luftre;
    The decompofition of acids and of metallic oxides;
    Decompofition;
    The alteration of mineral colours;
    Vegetation;
    The renovation of the vital air in the atmofphere;
    The decompofition of water by the leaves of plants;
    The formation of oils;
    The differences of nature, which diftinguifh the vegetables of hot, from thofe of cold climates.

A 3   C H A P.

C H A P. II.

The ACTION of CALORIC.

I. THAT which mankind in general call *Heat*, is *a fenfa-tion* produced by a fubftance which modern chemifts denomi-nate *Caloric*. Caloric applied to the human body, in a pro-portion larger than that in which it already exifts in it, warms our frame, and prefents heat to our fenfes. When matters lower in temperature than our body, are applied to it, there is a portion of its caloric abftracted ; and we feel, of confe-quence, the fenfation of cold.

II. Caloric penetrates through all the other fubftances in na-ture. It feparates their component particles from one ano-ther, and makes room for itfelf among them. It diminifhes their mutual attraction ; and dilates the bodies which they compofe. It fufes folids ; and rarefies liquids to fuch degree that they become invifible, affume the form of air, and are thus converted into elaftic, compreffible, aeriform fluids. Liquids are therefore combinations of folids with caloric ; gaffes are folutions of diverfe bodies in caloric. Caloric is of itfelf, the moft divided, the moft attenuated, the lighteft, and the moft elaftic of all the fubftances in Nature : And hence, its gravity cannot be eftimated.

III. Caloric augments the mutual attractions of contiguous bodies, precifely in the fame proportion in which it divides,

and

and diminishes the mutual attraction of the component par-
ticles of each of them. In consequence of this, it is succefs-
fully employed to effect new combinations ; and to promote
the reciprocal union of different bodies. Hence the axiom
*corpora non agunt, nifi foluta ; bodies act not on one another,
unlefs previoufly diffolved.*

IV. Every different body, having a form and an arrange-
ment of its conftituent particles peculiar to itfelf, requires a
peculiar quantity of caloric, to heat it to any given tempera-
ture : which is called *its* particular *capacity for containing
caloric.* From this it follows, that different bodies, even when
of the fame temperature, and when indicating the fame de-
gree of the thermometer, really contain different quantities
of caloric.

V. That particular quantity of caloric, which each differ-
ent body requires, to communicate to it any given tempera-
ture, is called its *fpecific caloric.* And as the differences of
this fpecific caloric in different bodies, cannot be meafured by
the thermometer ; there has been an *invention* produced, which
meafures the differences of fpecific caloric in different bodies
of the fame temperature, by afcertaining the quantity of ice,
which each of thefe bodies melts, while falling from the fame
higher to the fame lower degree of the thermometer. The
differences of the quantities of melted ice, indicate the diver-
fities of fpecific caloric in the different bodies thus compared.
The inftrument which this invention employs, is called a
Calorimeter.

VI. All the experiments of thofe modern philofophers who
have inveftigated the theory of caloric, concur to prove, that
bodies, when they change their ftate, fuffer alfo a change of
their refpective capacities for containing caloric. *By the
change of the ftate of bodies,* is meant, the alteration of their
folidity, liquidity, or elaftic fluidity. By the mixture, there-
fore, of any two folid bodies, of unequal temperatures, and
not entering into mutual combination, but having the fame

capacity for containing caloric, we fhall obtain a mafs. of an
exactly intermediate temperature.   But if thefe two bodies
be of unequal capacities for containing caloric, then the tem-
perature of the mixture will not be precifely intermediate be-
tween the temperatures of the two different bodies : And ac-
cording as it recedes more or lefs from the precife interme-
dium, will the difference between the capacities of the two
bodies be greater or lefs.

   VII. The foregoing facts fhew, that caloric has different.
attractions or degrees of affinity for different bodies.   In all
combinations, therefore, the varied attraction of caloric ought.
to be carefully obferved, and eftimated.

   VIII. When bodies enter into mutual union, they either
fuffer a lofs of caloric ; which fhews the new compound to
have a fmaller capacity than its conftituent parts had, for con-
taining caloric ; and in which cafe, the procefs exhibits heat.
to our organs, and the temperature of the mixture rifes ;.
as is the moft common effect: Or elfe the bodies entering,
into combination, abforb caloric ; and the new compound
contains more caloric, than its component parts contained
when they were feparate ; in which cafe, the mixed fubftances
cool, while the combination is taking place ; the caloric which
was before diffufed in a free ftate among their component
particles, is now more intimately combined with them ; and.
there is even an abforption of caloric from contiguous bo-
dies.

   IX. Caloric fometimes adheres fo tenacioufly to particular
bodies, as to hinder thefe from entering into combination with
other bodies prefented to them.   There are various fubftances,
which, when rarefied to the ftate of gazeous or elaftic flui-
dity, neither unite with extraneous matters, nor with one
another.   Double affinities muft be employed, if we wifh to
make them enter into new combinations, without having firft
changed their gazeous form.

                       2   X.

X. So powerful is the attraction of caloric for certain bo-
dies, that it is very often usefully employed to detach those
bodies from compounds in which they are combined; and to
analyse or decompose a variety of compound substances. In
distillation, and in processes of decomposition, effected by the
aid of fire, the whole process consists in the application of fire
or caloric to matters of an extremely compound nature.
These matters are thus gradually dissolved; and their prin-
ciples are severally detached in a vaporous or gazeous form,
and in the order of their solubility by caloric.

XI. It often happens, that light applied in conjunction with
caloric, aids its operation, and *vice versa*. Chemists find it
advantageous to use transparent vessels, which, when in the
furnace, admit both light and caloric together. The effect is
the same, when opaque vessels are sufficiently penetrated with
caloric, to become red-hot, or permeable by light.

XII. Some bodies absorb caloric much more rapidly than
others: And this property of absorbing caloric is termed
rather *the conducting of caloric*. Those bodies which are the
most highly coloured, are in general the best conductors
of caloric. But the cause of this phæ..omenon is un-
known.

XIII. All these facts agree in proving, that caloric is a pe-
culiar substance; not, as some philosophers have supposed, a
modification of all natural bodies. We know not, as yet,
whether it be same with light. The farther we advance in
the philosophical knowledge of Nature, the more differences
do we still continue to discover between the action of the one
of these bodies, and that of the other.

Application of the foregoing Axioms.
The Dilatation of folids; and the Rarefaction of fluids;
Thermometers;
Fufion;
Sublimation, and Volatilization;

The

The Calorimeter; a table of the specific caloric in differ-
    ent bodies;
The changes of temperature in different mixtures;
Artificial refrigeration;
The production, and the fixation of Gasses;
Distillation, with different temperatures;
Incandescence;
The different conductors of Caloric;
The attractions of Caloric.

C H A P.

CHAP. III.

The ACTION of AIR.

I. THE air acts in a mass, upon all the other bodies in Nature, by its weight, its dryness or moisture, its temperature, &c. Hence, processes of combination or decomposition to which air has free access, differ greatly from those performed *in vacuo*. And for this reason, it is always necessary, in chemical experiments, to pay careful attention to the indications of the barometer, the thermometer, and the hygrometer.

II. The atmosphere is a vast laboratory in which Nature continually performs numberless processes of analysis, solution, precipitation, and combination. It is an immense recipient, in which all the attenuated and volatilized products of terrestrial bodies, are received, agitated, mingled, combined, or separated. The air of the atmosphere may thus be regarded as a vague and confused mixture of mineral vapours, of minute particles of bodies animal and vegetable, of seminal grains and eggs; through which the luminous, the caloric, and the electric fluids, incessantly pass and repass in all directions. Those great changes to which it is liable; the operation of each of which, extends at once through a wide tract of space, and which are exhibited to our senses, in the

<div align="right">production</div>

production of water, light, free caloric, and noife; have re-
ceived the name of *Meteors*.

III. Although of a compofition fo extremely mixed, and
feemingly uncertain; yet is the air of the atmofphere, to
our perceptions, the fame in its primary qualities, whatever
the place from which the fpecimen is taken. Its particular
character is diftinguifhed by its two moft eminent properties—
of *maintaining combuftion*, and *being fit for* the falutary *refpi-
ration* of animals. Thefe two grand phænomena are fo near-
ly allied to each other, that a diftinct knowledge of the nature
of air, may be obtained by the careful obfervation of what
paffes in the cafe of combuftion.

IV. A combuftible body will not burn, unlefs it be in con-
tact with atmofpheric air, or with a certain fubftance extract-
ed from atmofpheric air. Combuftion cannot take place *in
vacuo*.

V. In any given quantity of air, a combuftible body can
burn only for a certain proportionate fpace of time. An
hundred parts of atmofpheric air, contain only twenty-feven
parts that can contribute to combuftion. After a combuftible
body fhall have abforbed thefe twenty-feven parts, the com-
buftion will then ftop; becaufe the remaining feventy-three
parts can be of no ufe to promote it. Atmofpheric air is a
compound of two different fubftances; having only fome
other extraneous matters mingled with it; which do not ex-
ceed an hundredth part of the whole. Of thofe two compo-
nent principles of atmofpheric air, *one* ferves for the purpofes
of combuftion and refpiration, and is called *Vital Air*; the
other, differing from vital air, in poffeffing qualities directly
contrary to *its* two moft eminent ones, is called *Gas Azote*.

VI. A body burning in common air, therefore, actually
analyfes this fluid; detaches the vital air; and by abforbing
it, gains an increafe of weight, and undergoes a change of
nature. The gas azote that remains, is lighter than atmo-
fpheric air; extinguifhes combuftion, and deftroys animal
life;

life; and is, as we shall hereafter see, a principle in the com-
position of many bodies, particularly of ammoniac or the vo-
latile alkali, of the acid of nitre, and of animal substances.

VII. A combustible body, after being burnt in atmo-
spheric air, and absorbing as much vital air, as it is capable
of receiving into combination with it; cannot again burn, al-
though it be immersed in fresh air; but has become incom-
bustible, and generally saline.

VIII. A body burning in atmospheric air, never entire-
ly absorbs the ,27 parts of vital air. To detach the whole
of the vital air, from any quantity of the air of the at-
mosphere, and thus to accomplish a complete analysis of the
latter; combustible bodies must be repeatedly immersed in it,
and the combustion renewed for several different times in suc-
cession.

IX. That portion of air which is thus absorbed by com-
bustible bodies, and which we have hitherto named *Vital Air*,
is likewise denominated *Gas Oxigene*. It has received the
first of these names, because it is the only elastic fluid fit for
the salutary respiration of animals. The *second* has been af-
fixed to it, because many bodies are, by the absorption of it,
rendered acid.

X. Combustion consists, then, in the fixation and absorption
of vital air by combustible bodies, and in the decomposition
of atmospheric air by these bodies. Since no elastic fluid but
vital air, can act the same part in combustion; it is easy to
conceive, that a body which is sufficiently combustible to ab-
sorb all the vital air out of a given quantity of atmospheric
air; may be employed as a means of ascertaining the precise
proportions in which the two elastic fluids of the atmosphere
are combined together in it. Phosphorus is, upon this prin-
ciple, at present used as an *Eudiometer*, to indicate the purity
of air, that is, to shew what proportion of vital air it con-
tains.

IX.

XI. As vital air is a *Gas*, and many combuſtible bodies, by
abſorbing, fix it, and make it take a ſolid form ; it muſt ne-
ceſſarily happen, that vital air, when thus precipitated, will
loſe the caloric to which it owed its elaſtic fluidity. Hence
comes that free caloric or heat, which is evolved during
combuſtion.

XII. Combuſtible bodies differ from one another, 1. In the
degrees of rapidity, with which they reſpectively abſorb
oxigene ; 2. In the quantities of oxigene which they reſpec-
tively abſorb ; 3. In the proportions of the caloric which
they ſeverally diſengage from the oxigene abſorbed ; 4. And
conſequently, in the more or leſs perfect ſolidity of the oxi-
gene contained in them all, after combuſtion.

XIII. Burnt bodies may therefore be defined to be *bodies
combined with oxigene.* They are called alſo, *oxigenated* or
oxidated ſubſtances. And ſince the greater part of thoſe bo-
dies which are known to us, are either *burnt* or *combuſtible ;*
there is reaſon for thinking, that a number of incombuſtible
natural bodies, the compoſition of which is unknown, may
poſſibly be hereafter found to be incombuſtible, only becauſe
they are already ſaturated with oxigene. In ſeveral inſtances,
this conjecture has been already confirmed by the progreſs of
chemical diſcovery.

XIV. From ſeveral of theſe preceding axioms, it follows,
that when we burn a combuſtible body, that it may give us
heat ; as, in our domeſtic apartments, in the cold of winter ;
we derive, not from the combuſtible body, but from the air
itſelf, the greater part at leaſt, of the caloric which exiſts in
combination with it. [It may even be aſſerted, that the
colder the air, ſo much the more heat does its decompoſition
afford ; for the colder the air is, the more is it condenſed ;
and ſo much the greater is its quantity in proportion to its
bulk. We know, that the heat of our common fires becomes
much more lively and intenſe, when the ſurrounding air is
ſuddenly cooled. The art, too, of increaſing combuſtion by

I   pouring

pouring a ſtream of freſh air, with bellows, upon wood alrea-
dy inflamed, is founded upon this principle *.]

XV. Combuſtion, therefore, decompoſes not only atmo-
ſpheric air, by the abſorption of one of its principles ; but al-
ſo the vital air abſtracted, by abſorbing, fixing, and ſolidifying
more or leſs, the oxigene or baſe of the vital air, in the com-
buſtible body ; and by diſengaging in greater or ſmaller abun-
dance, the caloric which was the ſolvent of that baſe.

XVl. Combuſtion exhibits another intereſting phænome-
non which has been explained by modern chemiſtry. This
is

* The Author ſeems here to miſrepreſent, or to expreſs obſcurely, the
true chemical fact. *Cool air* is cold and denſe, only for want of caloric,
to rarefy and warm it. Before the *caloric* can eſcape, and the *oxigene*
enter into combination with the *burning body;* the *vital air* muſt ever
be ſaturated with *caloric,* to that point at which the *attractions* of *oxigene*
for the *combuſtible body,* and of *caloric* for other contiguous ſubſtances,
are ſufficient to overcome the mutual attraction by which *caloric* and
oxigene are held in union, in *vital air.* Now, one combuſtible body may
indeed have a more powerful attraction for *oxigene* than another ; *oxi-
gene* may have abſorbed *caloric* beyond the due point of ſaturation :
And hence will the quantity of *caloric* vary, which is neceſſary to fit
vital air for ordinary *combuſtion.* But this variation is never ſuch as
the author ſeems in the text to ſuppoſe. Cold air is always rarefied
by the abſorption of a new quantity of the ſurrounding free caloric, be-
fore it enters into combuſtion. A ſtream of denſe, cold air, revives and
inflames combuſtion,—ſolely by the more rapid *mechanical* expulſion of
the freed *gas azote;* by the abſorption or expulſion of the evolved caloric,
which would otherwiſe have floated about, ſo as to make the proceſs
languiſh ; and by a removal of the aſhes, or the new compound of the
combuſtible body and oxigene, in conſequence of which, freſh parts of
the combuſtible body, are expoſed to the contact of the vital air. The
action of *bellows* in promoting inflammation, is thus almoſt wholly me-
chanical.—In reading thoſe ſentences of the text which I have incloſed
within brackets, it is to be carefully remembered, that, *cold air does
not neceſſarily contain more caloric, than the ſame bulk of hot air may contain;*
but only has *a capacity of containing more ;* which muſt *commonly be more
or leſs ſatisfied, before it can be decompoſed by combuſtion.* H.

is the difengagement of light, or the production of flame. It
is certain, that the greater part of the light which conftitutes
flame, is contained in vital air, of which it is a component
principle : 1. Becaufe combuftible bodies yield much more
flame, when they burn in vital air alone, than in atmofpheric
air : 2. Becaufe fome combuftible bodies afford no flame, un-
lefs when burning in pure vital air : 3. Becaufe, in order to
abftract oxigene out of bodies containing it, for the formation
of vital air; it is neceffary not only to diffolve the oxigene
in a greater or fmaller quantity of caloric, but alfo to add, at
the fame time, a due portion of light : 4. Laftly, Becaufe
there are burnt bodies, which, at the bare contact of light, are
deprived of their oxigene.   The laft of thefe four facts is ex-
preffed by the terms, *unburning* and *decombuftion;* phæno-
mena which were faid, in the firft chapter, to be produced by
the action of light.

XVII. Vital air is therefore a compound of *oxigene ;* a fo-
lidifiable, ponderous, acidifying bafe ; held in folution by
caloric, and *light ;* which are of themfelves fubftances in a
ftate of extreme attenuation, extremely elaftic, and having no
meafurable gravity.   Combuftion confifts in the more or lefs
perfect precipitation of oxigene from its union with thefe its
two folvents.

XVIII. A combuftible body, then, when burning, difen-
gages from vital air, not only caloric, but light alfo.   Every
different combuftible body difengages its own peculiar por-
tion, as well of light as of caloric, from vital air.   There are
probably fome combuftible bodies which difengage more of
caloric than of light from vital air ; and others again which
difengage from it more of light than of caloric.

XIX. Oxigene that is fixed in burnt combuftible bodies, is
therefore more or lefs entirely deprived of its light and ca-
loric.   The denfity, the folidity, which it then acquires, is one
of the caufes that regulate the more or lefs eafy feparation of
oxigene from burnt, combuftible bodies, for the formation of

new

new vital air. Some of thefe bodies require, in order to this, more of light than of caloric, while others take more of caloric than of light.

XX. From what is here faid, it is eafy to conceive, that the abftraction of oxigene from a burnt body, is a procefs directly the reverfe of combuftion. Our language wants a word to exprefs this operation. It may be faid to *unburn* or *de-oxidate* bodies: And hence we may derive *unburning* or *de-oxidation*, as names to denote the event accomplifhed.

XXI. Oxigene, befide adhering more or lefs tenacioufly to combuftible bodies, according as it is in its union with them, more or lefs folid, and has loft more or lefs of its folvents, caloric and light; is alfo attached to thofe bodies by virtue of its attractions, or peculiar affinities for every different one of them refpectively. We are already acquainted with many of thefe affinities of oxigene, for different bodies: And of fome of them, the precife forces even, have been correctly afcertained.

XXII. By means of thefe affinities, we often make oxigene to pafs from a burnt, into a combuftible body. A fpecies of combuftion then takes place, which is more or lefs tacit and fecret, in proportion as the oxigene is more or lefs folid in its combination with the burnt body, and more or lefs in the fame ftate of denfity, as the fubftance into which it is paffiug. But this fpecies of combuftion is fometimes accompanied with vivid flame and heat; phænomena which are exhibited, whenever the body which receives the oxigene, requires it in a ftate more folid than that in which it exifted in the fubftance now divefted of it. Thus iron, zinc, antimony, arfenic, &c. burn with flame, when heated in contact with oxide of mercury: They rob this oxide of its oxigene, and require the oxigene to become more folid, as it enters into combination with them.

B   The

The foregoing propofitions may be applied to explain

The refiftance which the air makes to evaporation, to the
    ebullition of liquids, to fublimation, &c.;

The folution of water in air, and the variations of the
    drynefs and moifture of the atmofphere ;

The efflorefcence and deliquefcence of faline bodies ;

Aqueous meteors ;

Experiments made at different heights in the atmo-
    fphere ;

Experiments made *in vacuo;*

The comparative natures of combuftible bodies ;

The increafe of the weight, and the change of the nature
    of thefe bodies after combuftion ;

The hiftory of native burnt bodies ;

Artificial flame and heat ;

The theory of furnaces ;

The different proceffes performed with *Eudiometers,* for
    afcertaining the degree of the purity of air ;

The refpiration of animals ;

The reduction of air to a mephitis by the effects of com-
    buftion and refpiration ;

The fupport, diminution, and augmentation of animal
    heat ;

Tranfpiration from the fkin and from the lungs, &c.

                                        C H A P.

CHAP. IV.

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The NATURE *and* ACTION *of* WATER.

I. WATER exifts in three different ftates. It is *folid* in *ice;* it is beft known as a *liquid;* it is expanded by rarefaction into *vapour* or *gas.*

II. Ice is a cryftallization more or lefs regular, tranfparent, highly fapid, elaftic; fufible at a temperature above 32° Fahrenheit; and which when entering into feveral new combinations, ftill gives out caloric, notwithftanding its previous apparent deftitution of heat.

III. Ice of the temperature of 32° of Fahrenheit's thermometer, requires to its fufion, precifely that quantity of caloric which would be fufficient to raife an equal quantity of water to the temperature of 167° Fahrenheit. Its capacity for containing caloric, is therefore not precifely the fame as that of liquid water: a difference owing to the peculiarity of the ftate of ice; as has been explained in the VI. Section of the II. Chapter.

IV. Whenever liquid water lofes much of its heat, in entering into a new combination; it may be confidered as becoming folid. In fuch combinations, it is often more folid than

ice

ice at the temperature of 32° F. Hence the folidity of mor-
tar, and other cements made with flaked lime.

V. Water remains eternally folid, on various mountains
which have been for ages chilled by the prefence of ice, as
well as under the poles. It there forms a fort of rocks, or
hard and white concretions, not unlike to ftones.

VI. Liquid water is pure and taftelefs, without fmell, and
850 times as heavy as an equal bulk of air. It forms rivers,
lakes, ponds, fprings, brooks, &c. It occupies cavities, fur-
rows, and in general all the loweft parts of the furface of the
globe.

VII. It is rarely pure. At the furface, and in the inte-
rior parts of the earth, it diffolves and retains air, faline gaffes,
and terrene falts. It even acts upon the moft folid ftones,
wears them down by attrition, depofites the particles which
it carries with it, and forms them into cryftallized figures.
It has been, on this account, named the great folvent of na-
ture. It gives rife to many phænomena; and is one of the
prime agents which are for ever modifying anew the furface
of the globe. Its motions, its currents, its action, have at
length changed the nature of minerals, and have created, as
it were, a fort of new world, upon the old.

VIII. All waters on the earth contain, therefore, fome ex-
traneous fubftances. The prefence of thefe may be recogni-
zed by the extraordinary fpecific gravity of the water; by
its tafte being more or lefs infipid, earthy, and crude; by its
averfion to boil, and its inability to foften pulfe, or to frothe
foap. That water is the moft pure, which is the fartheft
from poffeffing thefe qualities.

IX. Water, running over a bed of quartzofe fand, and in
contact with air, is fufficiently pure for the ordinary purpofes
of life, and of the arts. But, water which paffes through
chalk, plafter, or marble, or which ftagnates over *peat-earth,*
bitumen, mineral ores, or in fubterraneous caverns, at a
diftance

diftance from the action of the atmofphere ; is always more or lefs impure.

X. Chemiftry corrects the impurity, crudenefs, and hard-nefs of waters, by expofing them to the air, agitating them in contact with it, by boiling, diftilling, and then *aerating* them. The addition of afhes, alkalis, and light acids, ferves to re-move in part, the bad qualities of water, and fometimes even deftroys thofe qualities altogether. Moft of thofe extraneous bodies by which the purity of water is altered, being either much more volatile, or much more fixed in their nature than water; diftillation is therefore the fureft means for purifying water. Chemifts, for this reafon, ufe always diftilled water in their experiments.

XI. As liquid water is a combination of ice of the tem-perature 32° F. with fuch a portion of caloric as would be fufficient to raife a quantity of water equal to the quantity of ice employed, to the temperature of 167° F.; therefore ca-loric added to liquid water, rarefies it. At 212° F. water takes a gazeous form, and is diffufed in vapour. This va-pour is much lighter, and in proportion to its actual weight, is expanded into a much greater bulk, than liquid water. It eafily penetrates through all other bodies; and is diffolved in air. The elaftic efforts which it makes to expand itfelf, whenever it experiences an increafe of temperature, fit it for moving the largeft bodies.

XII. As liquid water abforbs air, and thus becomes lighter; fo air alfo abforbs and diffolves water. Hence the evapora-tion of water. This folution of water in air is dry and in-vifible, like the air; it follows the ratio of the temperature of the atmofphere. The hygrometer does not accurately in-dicate the prefence of water in this ftate ; for a perfect folu-tion of water in air, does not at all affect that inftrument. But water about to be diffolved in air, and ftill more water precipitated from this folution, never fail to alter the indica-tions of the hygrometer.

XIII.

XIII. Water is not, as it was long suppofed to be, a fimple body. Upon the rapid combuftion of various combuftible bodies, more or lefs intenfely heated; fuch as charcoal and pitcoal both previoufly kindled; iron red-hot, zinc in fufion and red-hot, oils, &c.; water prefented to thefe bodies in this ftate, undergoes a decompofition; and a quantity of oxigene derived from it, is fixed in the combuftible bodies.

XIV. While the *oxigene* from water *is fixed* in thofe combuftible bodies which it kindles and inflames; the other component principle of the water, being fufceptible of folution in caloric, forms *inflammable gas*, which is diffufed in an uncombined ftate. This fecond fubftance, as being one of the elementary principles of water, has been named *hydrogene*; and its elaftic fluid folution in caloric and light, has been called *gas hydrogene*. That difengagement of this fubftance into gas, which takes place whenever water is decompofed by a combuftible body, is the caufe of a great number of detonations and fulminations.

XV. The gas hydrogene obtained in very many chemical proceffes, comes always from water; *either* radically, and by the effect of a former decompofition, by which the hydrogene has been abftracted from water, and fixed in fome other body which now refigns it; *or* by the immediate and inftantaneous decompofition of water itfelf.

XVI. It has been afcertained by many experiments, that water contains about 0,85 of oxigene, and 0,15 of hydrogene. The compofition of water by a chemical procefs; one of the nobleft difcoveries of modern chemiftry; confirms the certainty of the analyfis of water. For, 0,85 parts of oxigene, added to 0,15 of hydrogene, give ,100 parts of pure water.

XVII. The decompofition of water by a combuftible body, is always effected by the double affinities—of the oxigene of the water for the combuftible body, and of caloric for the hydrogene of the water. On this account, the greater the quan-

tity

tity of the caloric matter employed; fo much the more rapid is always the decompofition of water by iron, charcoal, &c. From this need of a great abundance of caloric, in this procefs, an idea may be drawn, of the manner in which hydrogene, one of the component principles of water, comes to acquire a degree of levity fo much greater than that of the water in which it before exifted: A cubic foot of water weighing 70 lib.; while a cubic foot of gas hydrogene, weighs only 61 grains.

XVIII. Gas hydrogene, which is always *originally* derived from the decompofition of water; carries with it, ufually a confiderable portion of the body with which it was laft combined; and this either in fufpenfion or folution, according as that body was of a nature more or lefs mixed. It is commonly mixed with gas azote, with carbonic acid gas, or with vital air; or it holds in folution, water, carbone, fulphur, phofphorus, arfenic, oils, alcohol, æther, &c. According as its purity is contaminated by one or another of thefe different fubftances; it varies in odour, gravity, inflammability, the colour of its flame, its aftion upon different fubftances, and the extraneous produfts which, befide pure water, it affords, when burnt. Hence all the different fpecies and names of inflammable gas, the generic bafe of which, is always gas hydrogene.

XIX. Gas hydrogene being one of thofe natural fubftances which contain the moft caloric; is one of thofe combuftible bodies which the moft eafily fuffer their caloric to efcape; and which, by confequence, afford the moft heat, when burning. Hence, all compound, inflammable matters; fuch as oil, greafe, and in general all thofe which are obtained from organized bodies; having hydrogene for one of the moft abundant principles in their compofition; yield much heat, during their combuftion. Of this charafter, are alfo timber, oils, pit-coal, bitumen, alcohol, æther, &c.

B 4   XX.

XX. It follows alfo from the preceding facts, that compound, combuftible bodies, containing much hydrogene in their compofition; muft require, when they burn, a very large proportion of oxigene, and will afford water, as a product of their combuftion, in juft proportion to the quantity of hydrogene which they contain. Thus a pound of alcohol gives by combuftion, more than a pound of water, &c.

XXI. The combuftible bodies that decompofe water, are in general, thofe which have a ftronger attraction for oxigene than hydrogene has. But the efficacy of this attraction is greatly aided by the prefence of caloric, which for its part tends to combine with hydrogene. Great abundance of caloric, may even render water decompofable by bodies, which, if cold, would be unable to decompofe it. Light alfo contributes to the fame effect.

XXII. Combuftible bodies which, at whatever temperature, do not decompofe water, on account of the faintnefs of their attraction for oxigene; which is in this cafe always weaker than the attraction between oxigene and hydrogene;—will, on the contrary, after being burnt by other means, undergo decompofition by fuffering hydrogene to abftract the oxigene which they had acquired, when burning. This happens to the oxides of lead, bifmuth, &c.

XXIII. Chemiftry knows, as yet, no other means of decompofing water, but by prefenting to it, combuftible fubftances capable of detaching and abforbing its oxigene. We are acquainted with no bodies that we can apply in art, to abforb the hydrogene, and leave the oxigene difengaged. Nature however, poffeffes inftruments by which fhe can accomplifh this particular decompofition of water. The leaves of vegetables, when the rays of the fun fall upon them, feem to decompofe water, to abforb its hydrogene, and to evolve its oxigene into vital air. This appears to be, in part, the mecha-

nifm

aifn of vegetation, of the formation of oils, and of the renova-
tion of the atmofphere. See Chap. IX.

XXIV. While hydrogene and oxigene, diffolved each into
into gas by the efficiency of caloric and light; remain both
cold; they cannot combine, although brought into mutual
contact: no inflammation is produced by their mutual im-
pulfe; there is no water formed. But when a burning body
is prefented to the mixture, when it is powerfully com-
preffed, or if it receive any fudden and violent fhock: the
two gaffes then begin to unite; combuftion enfues; and wa-
ter is produced.

XXV. It fhould feem, that a like event happens in the at-
mofphere. Detonations in the air, or claps of thunder, are
probably nothing elfe, but the combuftion of hydrogenous gas
with vital air; and are accordingly followed, for the moft part,
by heavy fhowers of rain. Other tempeftuous rains ap-
pear alfo to be owing to the fudden formation of water in the
atmofphere; in confequence of the rapid combuftion of hy-
drogenous gas and vital air; occafioned by the electric fpark,
and by the neceffity for reftoring the electric equilibrium be-
tween one cloud and another, or between the clouds and the
earth.

XXVI. A multitude of chemical phænomena in nature and
art, that feemed formerly to be unaccountable and miraculous;
are now perceived to be neceffary confequences of the decom-
pofition of water. The influence of the general facts enume-
rated in this chapter, is very great, upon the whole theory
of chemiftry. They will recur to our notice in all the fubfe-
quent chapters.

Application of the preceding propofitions.

Artificial refrigeration;

Theory of icy mountains, and of the polar ices;

Varieties of the waters of the earth and atmofphere;

Art of correcting the bad qualities of water;

Theory

Theory of the ebullition of water;

Difference between boiled and aerated water;

Diftillation of water in large quantities;—of falt water;

Theory of mifts and dews;

Theory of the hygrometer; and of the phænomena mea-
    fured by it;

Inflammation of combuftible bodies by water;

Gaffes difengaged from the waters of marfhes;

The diverfity of inflammable gaffes;

Colouring by inflammable gaffes;

The oxidation of metals, or ruft formed by moift air;

Theory of detonation;

Some of the phænomena of the folntion of metals;

Some fundamental principles towards a theory of vegeta-
    tion, of the formation of oils, &c.

C H A P.

CHAP. V.

The Nature and Action of EARTHS *and* ALKALIS.

I. WHAT was formerly meant exclufively by the name of *Earth ;* and was fuppofed to be an *elementary* fubftance, the caufe of folidity, drynefs, infipidity, infolubility, &c.; is no longer to be regarded in any other light, than as one of thofe vague, indeterminate ideas, which the imagination diffatisfied with the fruitlefsnefs of experiments, often frames to amufe it, inftead of facts. We now acknowledge no fuch thing as *elementary* earth. Inftead of one, we have attained to the knowledge of five terrene fubftances ; each of which has an equal right to be termed *elementary*, fince each of them is found to enter into very many compounds.

II. Of the five fimple terrene fubftances which have been difcovered, there are two in fome fort more eminently earthy than the reft, more dry, more fufceptible of hardnefs, more infipid, &c. The other three poffefs faline qualities which give them a fimilarity of nature, to alkaline fubftances. Thefe laft three have been therefore denominated *Salino-terrene, faline earths, alkaline earths, terrene alkalis.* The two firft are *filices* and *alumines.* The latter three are *barytes, magnefia,* and *lime.*

III. Each of thefe five earths, is diftinguifhed by *fpecific* charaƈters, befide thofe *generic* qualities which belong to all the five, in common. Their generic charaƈters are, drynefs, unalterability by fire, the property of not being liable to decompofition, and of aƈting, in combinations, as fimple, indeftructible fubftances.

IV. *Silices*, has been named alfo *filiceous earth, quartzofe earth, vitrifiable earth.* It is rough to the feeling of the hand : it fcratches and wears down metals ; it is infufible, and incombuftible ; infoluble in water or acids—at leaft the greater number of acids ; it is foluble by alkalis, when expofed in contaƈt with them, to an intenfe heat, and in confequence of this folution, forms with them a glafs. This fimple earth is found in great abundance, in fand, quartz, flint, agate, jafper, grit, and in all fcintillating ftones, which, indeed, have it for their bafes. It has not, as yet, been either decompofed, or imitatated by fynthefis. It has been confidered as the fimpleft of all earths, the element of earth, the principle of every other fort of earth : but thefe opinions have not hitherto been juftified by obfervation or experiment. It is applied to a multiplicity of ufes, for mill-ftones, the manufaƈture of glafs, cements, pottery, &c.

V. *Alumines*, fo named, becaufe it forms the bafis of alum, is called alfo *Argill*, by fome writers. It is foft to the finger, adheres to the tongue, forms a pafte with water, hardens in the fire. It combines with moft acids, dries into flakes, and affumes extraordinary hardnefs when mixed with water and *filices* together. It is contained in a large proportion, in common clays, in pipe-earth, in fchiftus, fteatites, &c. In many of the arts it is employed, as a fubftance adapted to receive and retain any artificial form, which may be baked by the fire, and which is fit to refift the penetration of water. Its intimate nature or component principles are unknown ; it has been erroneoufly regarded, as *filices* altered, divided, and mouldered down by the aƈtion of air and water.

VI. Barytes, or *ponderous earth,* is a fubftance remarkable for its extraordinary gravity. In nature, it is never found alone, but always in combination with the fulphuric or the carbonic acid. It takes a green or blue colour, when expofed to the action of fire, in contact with the filices, or alumines of the crucible. In nine hundred parts of water, it diffolves; it communicates a green colour to the fyrup of violets; it has a greater affinity than even the alkalis with moft of the acids; its origin is unknown; but it is fufpected to be a metallic oxide; it ferves, at all times, to detect the prefence, and afcertain the quantity of the fulphuric acid.

VII. Magnefia is a fubftance very fine and white; not fubject to alteration by fire; foft and light; it refembles the feculum of vegetables, and requires nearly two thoufand parts of water to diffolve it. It communicates but a faint greennefs to the tincture of violets and mallows; with acids, it forms falts which are very foluble, and in which the magnefia is combined with a force of attraction fo much lefs than that with which lime adheres to acids, that they are all liable to be decompofed by lime. The attraction of magnefia for the acids, is nearly the fame as that of ammoniac; accordingly ammoniac and magnefia entering together into combination with acids, thus form a clafs of triple-falts, or falts with two bafes. This earth exifts in a fufficiently perceptible proportion, in ferpentines, mica, flate, amianthus. Like the preceding earths, it is indecompofable, and of unknown compofition.

VIII. Lime, the moft alkaline of all the earths, is the only one that has an acrid tafte, hot, almoft cauftic, difagreeable, and urinous. It gives a dark-green tinge to fyrup of violets, and when flaked in the open air, attracts moifture from the atmofphere. Under the action of water, it becomes exceedingly hot, and abforbing the water, becomes folid, in combination with it. When flaked barely by expofure to the atmofphere,

mofphere, it gives out caloric, largely : it is foluble in lefs
than feven hundred times its own weight of water. Diffol-
ved, it attracts carbonic acid from the atmofphere ; and on
the furface of the folution, forms a pellicle of chalk which has
been improperly termed *Cream of Lime.* Alone, it is unal-
terable by fire ; but with filices and alumines, is reducible to
fufion.   It is plainly a compound ; but its component prin-
ciples are unknown.

IX. That earths are occafionally converted into one another,
is merely a vain dream of naturalifts.   We have no proofs,
that filices is by long expofure to the air, changed into alu-
mines ; that flints are transformed into chalk ; that chalk is
converted into magnefia; as has been too haftily inferred from
fome flight and cafual appearances.

X. The three alkaline earths have more the appearance of
being compound, than magnefia or lime.   We have reafon to
believe, that azote is one of their component principles ; and
that they owe to it their alkaline properties.   Yet this opi-
nion has not hitherto, been fufficiently confirmed by experi-
ments.   The formation of the alkalis, is, indeed, with great
probability, afcribed to marine animals ; and the fact that
thefe contain much azote, feems to fuggeft, that azote is the
grand alkaligenous principle in Nature.

XI. It has been fuppofed, that the five earths are of a me-
tallic nature ; and it has been pretended, that by violent igni-
tion with charcoal, their reduction into the metallic ftate, has
been effected.   But thofe very few, and very fmall metallic
globules which have been in fuch inftances obtained, came
evidently from the charcoal, and from the earth of the cu-
pels : and thofe having been difcovered to be phofphure of
iron, whatever the earth in the treatment of which they were
procured ; it is hence evinced, that the earths afford no me-
tallic matters.   Some philofophers indeed continue to regard
the earths, as a fpecies of burnt bodies, in which oxigene is
extraordinarily adhefive ; and which, on account of this ad-

hefion,

hefion, cannot be decompofed. But, this opinion is, as yet, unconfirmed by obfervation or experiment.

XII. Earths combine with one another; two and two, three and three, and even in compofitions more complex; by proceffes unknown to us, but which Nature continually accomplifnes in the great way; by them, producing ftones various in hardnefs, ftructure, tranfparency, opacity, colour, form, &c. Art cannot imitate thefe compounds, for want of time, of fufficient maffes of the materials, and of an adequate extent of fpace. Yet it produces fomething fimilar to the natural compounds of the earths, by preferving long in mutual contact, mixtures of the earths, which have been well wrought together, and at the firft, moiftened with a little water.

XIII. The three alkaline earths hold an intermediate place between the earths and the alkalis; and are alfied alike to both. The alkalis are known by their acrid, burning, urinous tafte, their caufticity, their peculiar action on the fkin and all other animal matters, their converting the blue colour of violets to a green or even a greenifh yellow, and their deliquefcency. The known fpecies of alkali, are three, potafh, foda, and ammoniac. Of thefe, the two former are named *fixed alkalis;* becaufe they melt and become red in the fire, before being volatilized: the third, as being in this refpect, of an oppofite nature, is termed *volatile alkali.*

XIV. Potafh is known by the following characteriftics. It is dry, folid, white, cryftallized in rhomboidal plates, fufible at the temperature of 235°, extremely deliquefcent; it abforbs water with the evolution of heat, and a peculiar, faint odour; by fufion, it combines very well, and forms a tranfparent compound with filices. In nature, it is often found with lime, and in combination with different acids. It is obtained more efpecially from vegetables; in the afhes of which it remains, after their combuftion. It has been thought to have fuch a refemblance to lime, that it might poffibly be formed by the combination

combination of that fubftance with azote. But this opinion is unconfirmed by experiment.

XV. Soda is obtained by the incineration of marine plants, and forms alfo the bafis of common fea-falt. It has a re-markable refemblance to potafh in its form, caufticity, fufibi-lity, deliquefcency, its fufion with filices, its action upon ani-mal matters, &c. It long was, and ftill might be confounded with potafh. But the neutral falts which potafh forms in combination with acids, are entirely different from thofe which foda forms with the fame acids. Soda has been fuppofed to be a compound of magnefia with azote; becaufe falts with a bafe of magnefia, are as often found together with falts which have foda for their bafe, as calcareous falts, with fuch as have for their bafe, potafh. But neither the one idea nor the other, is well founded.

XVI. Ammoniac or *volatile alkali*, differs greatly from the two preceding fpecies. Its form is gazeous and peculiar, when it is diffolved in caloric; diffolved in water, it has a liquid form equally peculiar ; its odour is lively and fuffoca-ting ; it is foluble in the air ; it is known to be eafily decom-pofable by the electric fpark, by metallic oxides, and by the nitric, or the oxigenated muriatic acid. This decompofition has fhewn ammoniac to be a compound of hydrogene with azote ; and in confequence of this circumftance, it often ex-hibits the phænomena of a combuftible fubftance. This alfo explains the reafon why animal matters under putrefaction, give out ammoniac.

XVII. Should azote hereafter be afcertained to be the prin-ciple to which alkalis owe their formation ; the atmofphere will then appear to be a compound of *oxigene* and *alkaligene* each diffolved, feparately, in caloric. It will appear to be a vaft refervoir, out of which the philofopher may behold na-ture drawing the materials of the two claffes of compound agents which are the moft active, and the moft ufeful, in very many of her operations.

The

Application of the Propositions in this Chapter.

The extraction, the preparation, and the purification of
earths.

The theory of the arts of making earthen-ware, bricks,
tiles, pottery, porcelain ;

The theory of cements and mortars ;

The reciprocal combinations of earths by fire ;

The natural history of earths and stones ;

The compound nature of earths and stones ;

The natural alterations of stones ;

The changes of colours by the alkalis ;

Vitrification, and the processes of the glafs-maker ;

The extraction and purification of potash and soda ;

The theory of alkaline caustics ;

Some particulars relative to putrefaction.

C

CHAP.

C H A P. VI.

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The Nature of COMBUSTIBLE BODIES.

I. COMBUSTIBLE bodies are too numerous, various, and important in the phænomena which they prefent, and the combinations with one another and with air, into which they continually enter; not to deferve to be examined with the utmoft care, in order to the difcovery of their different properties and fpecific charaders.

II. Comprehending under this denomination, all fubftances that are capable of entering, more or lefs rapidly into union with oxigene, and of difengaging from vital air, its light and caloric: We muft next diftinguifh thofe fubftances into two claffes; fimple or undecompounded, combuftible bodies; and thofe combuftible matters which are, in their nature, more or lefs compound.

III. We call thofe combuftible fubftances, fimple, which chemiftry has not hitherto been able either to decompofe, or to form fynthetically. Their intimate nature is unknown. They are found fometimes folitary, in the mineral kingdom, or in the two other kingdoms of nature; but almoft always combined two and two together. Of this charader are diamond, hydrogene, fulphur, phcfphorus, carbone, and all metals.

tals. Each of thefe fix genera, is worthy of being examined
by itſelf.

IV. *Diamond* is the hardeſt of all bodies. It is very re-
markable for the force with which it refracts and decompofes
light; and from which NEWTON inferred, that it was highly
combuſtible. In nature, it exiſts cryſtallized in octóhædra,
duodecahædra, &c. It has fome varieties of contexture, den-
fity, and colour. It burns with a perceptible flame; and
while it burns, is reduced to vapour. Its combination with
oxigene is ſtill unknown. Few bodies act upon it; were it
not for its combuſtibility, it might be fuppoſed abfolutely
unalterable. We know of no compound bodies into which
it enters, as a component principle: of all the bodies in na-
ture, it feems to be the leaſt fubject to chemical attrac-
tion.

V. *Hydrogene* is one of the component principles of water;
and in combination with caloric and light, forms gas hydro-
gene. The weight of this gas is to that of atmofpheric air, as
one to *ſixteen*. It is infoluble in moſt other fubſtances; but, on
the contrary, diſſolves fulphur, phofphorus, carbone, arfenic,
oils, &c.; and by thefe folutions forms various forts of inflam-
mable gas; which are at prefent named *fulphurated, phofpho-
rated, carbonated, arfeniated, oleaginous, &c. hydrogenous gas.*
It decompoſes feveral metallic oxides, and fome acids, of which
the *radical* principles are fimple and well-known. To all its
compounds, whether combuſtible or incombuſtible, it com-
municates a confiderable refringent power. Becaufe water
poſſeſſed this power of refraction, NEWTON ſkilfully conjectu-
red, that it muſt contain fome fuch combuſtible fubſtance, as
this which has been at laſt difcovered in its compofition. Hy-
drogene is alfo fixed in organic bodies, and forms a principle
of thofe mixed, combuſtible matters which they contain. *See*
Chapters IV. and X.

VI. *Sulphur* is a yellowiſh fubſtance, odorate, electric, tran-
fparent, and octohædral, opaque, and prifmatic, fufible, and

fubject

ſubjeᏨ to two different ſorts of combuſtion. Of theſe com‐
buſtions, one is ſlow, with a bluiſh flame, and yields ſulphu‐
ᵳeous acid ; the other is rapid, with a white flame, and pro‐
duces ſulphuric acid. Sulphur enters into combination with
earths and alkalis; and by theſe combinations is rendered
ſoluble, It unites with metals, and forms with them ſulphu‐
reous ores, which exiſt in great abundance, in the earth,
and either in a ſolitary.ſtate, or in combination with pure
metals.

VII. *Phoſphorus* is a white ſubſtance, tranſparent, cryſtal‐
lized, lamellated, and very fuſible. It is ſubjeᏨ to two dif‐
ferent ſorts of combuſtion ; burning, either ſlowly, at any
known temperature, with a whitiſh flame, an acrid odour,
and the formation of phoſphorous gas ; or at the tempera‐
ture of 167°, rapidly, with a vivid and very brilliant flame,
without any ſenſible ſmell, and with the formation of phoſ‐
phoric acid. On account of its extreme combuſtibility, it is
never found pure, in nature. It enters with ſufficient readi‐
neſs, into combination with ſulphur, and metals. It diſſolves
in gas hydrogene ; detaches the oxigene from various me‐
tallic oxides ; ſeparates the metals from the acids, in the per‐
feᏨion of their metallic form and luſtre. It exiſts in minerals,
even more abundantly than in animals, to which it was for‐
merly ſuppoſed to be peculiar.

VIII. *Carbone,* the combuſtible matter of coals, when pure
from earth, alkali, ſalts, &c. may be burnt, if ſubjeᏨed to
an intenſe heat. With oxigene, it forms carbonic acid. Of
all known ſubſtances, it has the ſtrongeſt attraᏨions for oxi‐
gene ; which it detaches from all other burnt bodies. It
exiſts in a large proportion, in both animal and vegetable
matters of all ſorts. Of vegetables, it is almoſt the only ſo‐
lid baſe ; and on this account, ſtill remains in their form,
after they have been decompoſed, either ſpontaneouſly, or by
the aᏨion of caloric. It diſſolves in the alkalis, and in gas
hydrogene. It unites with metals ; forming, particularly,
with

with iron, carbure of iron; which is found in all the king-doms of nature, and has been improperly termed *Lead-ore, Plumbago,* and *Black-lead.*

IX. The metals are well known by their ponderofity and brilliancy. They are fufible, cryftallizable, combuftible. They decompofe water and various acids, combine with ful-phur, phofphorus, carbone, and with one another, at differ-ent temperatures. In the ftate of oxides, they act in refpect to the earths and alkalis, the part of acids; and again ferve to the acids, as fo many falifiable bafes. This genus differs from the preceding genera, in poffeffing many fpecies. In order to give a fhort account of thefe fpecies, of which there are now feventeen, well known,—a number which will proba-bly be much enlarged by future inveftigation; I fhall divide this *Genus* into five *Sections.* In the firft fection I fhall comprehend metals brittle and acidifiable; which are three fpecies; arfenic, tungften, and molybdena. To the fecond fection, I refer metals that are brittle, and oxidable on-ly; being five fpecies; cobalt, bifmuth, nickel, manganefe, and antimony. The third fection will include two fpecies of metals which are femi-ductile and oxidable; zinc and mer-cury. To the fourth fection belong metals which are highly ductile, and eafily oxidable; fuch as tin, lead, iron, and copper. Laftly, To the fifth fection remain thofe metals which are high-ly ductile, but not eafily oxidable; and thefe are the three fpecies of filver, gold, and platina. As the *ninth chapter* is entirely appropriated to the purpofe of explaining the moft important chemical properties of metals, it will be fufficient here to mention briefly, fome of the fpecific differences by which thefe bodies are diftinguifhed from one another. It may be proper to obferve, that the names of *femi-metals, im-perfect metals, perfect metals,* having been, evidently, derived from the errors of alchemy, ought to be banifhed from the language of a fcience that has now attained to confiderable accuracy.

A. *Arsenic* appears in plates of a bluish grey colour, brilliant, brittle, and which burn with a blue flame, and with the exhalation of a smell of garlic.

B. *Tungsten* is of a greyish white colour, granulated, friable, almost infusible, almost insoluble in acids, but very easily oxidable and acidifiable by air and caloric.

C. *Molybdena* presents itself in a powder, or in blackish grains which are brilliant, agglutinated, brittle, scarcely fusible, and which burn into a white oxide, that is volatile, prismatic, and acidifiable.

D. *Cobalt* is granulated, fine, of a rose-white colour, brittle and pulverizable, not easily fusible, and becomes blue, when it is melted with glass.

E. *Bismuth* appears in large plates of a yellowish white colour, brittle, very fusible, very crystallizable, very oxidable.

F. *Nickel* is grey, granulated, hard, not brittle, scarcely fusible, and yields a green oxide, under the action of calorie and air.

G. *Manganese* is of a greyish white colour, fine-grained, brittle; not fusible without great difficulty; the only metal combustible in the open air, and which instantly changes its colour, and is, within a few days reduced to a black powder. To preserve manganese from this spontaneous combustion, it must be kept in alcohol, or oil.

H. *Antimony* is white, pure, with large plates, brittle, difficult to melt; yields by combustion in the open air, a white oxide, which is sublimated and crystallized; and which combines with the alkalis in the same manner as an acid.

I. *Zinc* is of a bluish white colour, in large plates, semi-brittle, not without some degree of malleability, easily fusible, the most inflammable of all metals; when red-hot, it burns with a beautiful, yellowish white flame; it decompofes water with great energy.

K.

K. *Mercury* is fuſible at the temperature of 35½° below zero in Fahrenheit's thermometer ; and at 38° under zero, congeals. It may be reduced to a black oxide *(æthiops per ſe)* by mere diviſion ; and this ſimple proceſs extinguiſhes and fixes it in all thoſe thick or viſcid matters with which it is uſually triturated.

L. *Tin* is a gliſtering white ſubſtance, ſoft, light, ſcarcely ſonorous, ſuſceptible of being ſcratched by the nail, very fuſible, very combuſtible ; which yields a white oxide that impairs the tranſparency of glaſs, and converts it into enamel.

M. *Lead* is bluiſh, duſky, ſoft, heavy, eaſily fuſible. It yields an oxide, more vitrifiable than the oxide of any other metal, and a glaſs of a topaz-yellow colour.

N. *Iron* is white, fibrous, the moſt tenacious of all metals, very averſe from fuſion, very combuſtible, the only metal attractable by the magnet. It acts with great efficacy in decompoſing water ; is reduced to a powder, by expoſure to the open air ; combines with charcoal, which converts it into ſteel ; and is the only metal that abounds in the two organic kingdoms of nature.

O. *Copper* is of a beautiful, gliſtering red colour. It is very ſoft, very ductile, odorate, poiſonous. It burns with a green flame: its oxides are brown, blue, and green. The green oxide requires humid air to its formation.

P. *Silver* is white, pure, and brilliant, without ſmell and without taſte, highly ductile, not oxidable by caloric and air. It burns with a greeniſh flame, when acted upon by the electric ſpark. The vapours of ſulphur, blacken it. By the action of air alone, it is unalterable.

Q. *Gold* is of a beautiful, glittering yellow colour, highly ductile, leſs combuſtible and oxidable than ſilver, leſs alterable than ſilver by the contact of air. The electric ſpark reduces it to an oxide of a beautiful purple colour.

C 4

R.

R. *Platina* is the heavieft of all metals, of a greyifh white colour, with little brilliancy; the moft infufible, the leaft combuftible, the leaft alterable of all metals. It may hereafter become one of the. moft valuable inftruments of the arts.

X. Compound combuftible bodies are fuch as refult from the mutual combination of two or more of the foregoing fimple combuftible fubftances. The folutions of fulphur, carbone, phofphorus, arfenic, in gas hydrogene; are inflammable compounds. The combinations of fulphur with phofphorus; of carbone with iron; of metals with fulphur, with phofphorus, or with one another; are fo many compound combuftible bodies. Thefe are the combuftible matters, the moft common in nature. Art feparating them from one another, obtains them pure and folitary.

XI. A comparifon of the properties of compound combuftible bodies with thofe of the fimple, fhews that the former fometimes abforb oxigene more eagerly than their component principles would do if feparate; as in the inftances of many alloys and metallic fulphures : but that, on the other hand, fome compound combuftible matters are rendered more averfe from burning than their principles difunited would be, by means of that ftrong energy of attraction which thefe principles exert one upon another; as is the cafe with all phofphorated metals in general. Some of thefe combuftible compounds remain long unalterable in the air; feem to have in fome manner loft their combuftibility, by their mutual combination; and are at laft kindled, only by the application of a ftrong heat to them : Of this character is carbure of iron, which has been ufefully employed to preferve iron from rufting.

XII. Hydrogene and carbone are united in the moft intimate manner in the capillary tubes of vegetables. They often contain in their combination, fmall portions of earth, alkalis,

kalis, and acids, but eſpecially of oxigene. They form bitu-
mens, oils, and reſins; which, although tending to combuſtion,
and a ſeparation of their principles; yet remain for ſome time
in the equilibrium of combination; until a ſudden riſe of tem-
perature, and the contact of air or water, deſtroy the equi-
librium, divide the elements of the compound, and bring them
ſeparately into union with oxigene. The products of the com-
buſtion of thoſe compounds, are always, water and carbonic
acid. The ſame thing takes place in the caſe of alcohol and
æther, which are formed by modifications of the principles of
vegetables, and which, in an ultimate analyſis, are found to be
merely combinations of hydrogene and carbone, with more
or leſs of oxigene and water. *See* Chapters X. XI. and
XII.

XIII. This ſhort view of the different ſpecies of combuſtible
ſubſtances, and of their principal characteriſtic properties,
ſhews what an important part theſe bodies act in the phæno-
mena of nature. It authoriſes us to divide almoſt all natural
products into two great claſſes; *combuſtible* bodies, and *burnt*
bodies. In the magnitude and the action of the former claſs,
we ſee the cauſe of inflammable meteors, partial heats, volca-
noes, perpetual changes of the ſurface of the earth, &c. In
the exiſtence of the ſecond claſs, we perceive the ſource of the
varieties and number of the acids, of the compound ſalts, of
oxides and metallic ſalts, which diverſify in a thouſand ways
the aſpect of ores in the earth; the reciprocal decompoſitions
of theſe ſubſtances; and the alterations they undergo from wa-
ter, air, and light. Vegetables appear to be ſo many machines
organized by nature, in order to accompliſh the intimate mu-
tual combination of many of theſe combuſtible ſubſtances;
and thus to produce compounds, the unpermanency of which,
makes them peculiarly ſerviceable to the grand deſigns of
nature.

Application

Application of the foregoing propositions.

The hiſtory of the combuſtion of every different combu‑
   ſtible body, in particular detail.

The hiſtory of ſulphurated ſoils, and of native ſulphuric
   acid.

The phænomena of natural inflammable gaſſes in quarries,
   mines, the atmoſphere, &c.

The properties of terrene, alkaline, and metallic ſulphures.

The converſion of ſulphures into ſulphates and ſulphites,
   by the action of air and water.

The properties, extraction, and combinations of phoſpho‑
   rus; metallic phoſphures.

The exiſtence of metallic carbures in nature.

The phænomena which reſpect the denſity, the gravity,
   the ductility, and the fuſibility of metals.

The properties and uſes of alloys.

The formation of ſecondary ores; by tranſition from na‑
   tive metallic ſalts.

Volcanoes; ſulphureous and bath waters.

Bitumens; the compariſon of ſulphur, charcoal, and other
   ſimple combuſtible bodies, with oils, &c.

C H A P.

CHAP. VII.

The FORMATION *and* DECOMPOSITION *of* ACIDS.

I. ALL acids refemble one another in tafte; in their man-
ner of giving a red colour to vegetable fubftances; in their
common tendency to combine with earths, alkalis, and metal-
lic oxides; and in the property of attracting and being highly
attractable. It was therefore natural to conclude, as did Sir I.
Newton, that they refembled one another alfo in their in-
timate effence, and poffeffed fome homogeneous principle com-
mon to them all. This truth, chemical analyfis, with the affift-
ance of the new inventions in chemiftry, has afcertained be-
yond a donbt.

II. Since every acid contains oxigene, and lofes its acidity,
in proportion as it is deprived of this principle: Acids are
therefore to be regarded as burnt or oxigenated bodies, which
refemble one another by containing, all, more or lefs of the
fame acidifying element.

III. The nature of acids, may be examined in two ways;
either by producing them from their elements by combuftion,
uniting oxigene with fubftances liable to be acidified by it;
or by decompofing, and *unburning* acidified bodies, fo as to de-

tacl

tach the oxigene, by means of other fubftances having a ftronger affinity with it.

IV. Confidered in this laft point of view, all known acids may be arranged in three claffes; 1. Acids which we can both compofe and decompofe, and with the nature of which we are fully acquainted: 2. Acids which we can compofe, but not decompofe, and with the nature of which we are, by confequence, more imperfectly acquainted: 3. Acids which have not been, as yet, either compofed or decompofed, and of which the nature is, by confequence, wholly unknown to us.

V. Of nearly thirty fpecies of known acids, there are, ftrictly fpeaking, only three, of the intimate nature of which we are entirely ignorant, as having been hitherto unable either to compofe or decompofe them. We may, therefore, regard the character of acids in general, as being well afcertained; and may proceed to confider them in their general properties, and with refpect to their compofition.

VI. All acids are, then, compounds of *oxigene* with *fome other body*: The *former* principle, common to them all, being the caufe of their general refemblance, and of thofe qualities in which they all agree; while the *latter*, which is different in every different acid, prefents itfelf as the fource of thofe fpecific qualities which are peculiar in each. The peculiar materials combined with oxigene in the various acids, are, on this account, called the *radical* or acidifiable principles.

VII. The acids are, then, all combinations, of the *radical* or acidifiable principle-peculiar to each fpecies, with oxigene, a principle common to all the fpecies. Hence it follows, that their common properties, which give them the acid character, depend on oxigene; and that their mutually diftinguifhing qualities, which mark their fpecific characters, are owing to their radical principles.

VIII. The term *Acid* denoting the effential, general nature of thefe fubftances, forms the generic name. The peculiar

name

name of the radical principle, added to that of the genus, may ferve to diftinguifh each acid in particular. Thus, fulphur is the *radical* of the *fulphuric* acid ; phofphorus, of the *phofpho-ric* acid ; carbone of the *carbonic* acid, &c.

IX. Although this nomenclature poffefs the advantage of expreffing, with precifion, the nature of every different acid, yet, it has not, hitherto, been applied to all the acids; becaufe the radicals of fome of them, are ftill unknown; and of others, the radicals are themfelves fo compound, that their names could not be introduced into thofe of the acids to which they refpectively belong, without producing too great a multipli-city of words.

X. The acidifiable radicals may be combined with more or lefs oxigene ; and in this view, are fufceptible of two different ftates of acidification. In the *one*, they are combined with the fmalleft portion of oxigene that is not infufficient to render them acid ; and in this cafe, their acidity is very weak, and they act with but little energy on thofe bafes which form with them, neutral falts : In the modern fyftematic chemical nomenclature, this ftate of combination and acidity, is denoted by terminating the name of the weak acid in the fyllable *ous :* Thus, we fay the fulphureous, the nitrous, the phofphorus, the acetous acid, &c. The *fecond* ftate of acids, is that in which they contain a larger proportion of oxigene, (and are for the moft part completely faturated with it : They then poffefs all the attractive energy of which their acid nature is capable ; and this ftate is expreffed in the new nomencla-ture, by the final fyllable *ic*, in contradiftinction from *ous :* Thus we fay the fulphuric, the nitric, the phofphoric, the acetic acids.

XI. In regard to the proportion of oxigene combined with the acidifiable radicals, what is faid in the laft fection, may even be greatly extended in its fignification. Every radical may be confidered as capable of exifting in four different ftates : 1. As containing very little oxigene, not even enough

to give it any thing of an acid nature ; and in this ftate, it is but an oxide ; fuch as fulphur coloured red or brown by ex-pofure to the air ; which is but an oxide of fulphur : 2. As containing more acid, than in the former cafe, fo much as is fufficient to render the compound a weak acid; and fuch is the fulphureous acid, &c.: 3. As containing ftill more oxigene than in the fecond cafe, and being now fo faturated, as to con-ftitute a powerful acid ; fuch is the fulphuric acid : 4. Laftly, As containing a portion of fuperfluous oxigene, above what is requifite to render it a ftrong acid ; it is now called an *oxi-genated,* or even a *fuper-oxigenated acid.*

XII. From thefe foregoing facts, it appears, that there are two ways of forming acids at pleafure, with thefe feveral pro-portions of oxigene. In *one,* we combine the radicals with the quantities of oxigene which are precifely neceffary to bring them into the new ftate that we defire to produce ; as is done with fulphur, phofphorus, and arfenic. In the *other,* we detach from thofe acids which contain the greateft poffible quantity of oxigene, certain proportions of the acidifying prin-ciple, by means of thofe combuftible boffies with which it moft eagerly combines.

XIII. This laft method depends on the attractions of oxi-gene for the different combuftible bodies, and is often fuccefs-fully employed, to effect the entire decompofition of acids, by abftracting all the oxigene contained in them. Acids, by this means, inflame combuftible fubftances. In order to this, it is only neceffary, that the acids employed, contain no folid oxi-gene; and that the inflammable matters brought into contact with them, be able to abforb the oxigene which thofe acids contain, into a ftate more folid than that in which it exifts in the acids. It is not, however, every one of thofe acids which are decom-pofable by combuftible bodies, that can heat the combuftible matter to inflammation.

XIV. Heated charcoal is employed with fufficient fuccefs, to decompofe all the acids fufceptible of this decompofition.

r   But

But there are other combuftible bodies which ferve the fame purpofe. Such are moft of the metals, phofphorus, fulphur, hydrogene in that dry and folid ftate in which it exifts in its vegetable compounds.

XV. All the acids owing, as has been explained, their fpecific differences to their refpective radical principles; they may be diftributed into four claffes, the diftinctions of which fhall be founded upon the *nature* of the radicals, as it is *known* or *unknown, fimple* or *compound.*

A. The *firft* of thefe claffes, contains thofe acids of which the radicals are known and fimple; that is, which are formed of undecompofed combuftible fubftances, united with oxigene. It comprehends the following fpecies; the fulphuric acid, the nitric acid, the carbonic acid, the phofphoric acid, the arfénic acid, the tunftic acid, and the molybdic acid.

B. The *fecond* clafs include acids having unknown radicals, but fuch as are ftrongly fufpected to be fimple. The muriatic acid, the fluoric acid, and the boracic acid, are of this character.

C. I rank in the *third* clafs, acids of which the radicals are known to be of a binary compofition. Such are the vegetable acids, whofe common radical is compofed of hydrogene and carbone. The fuccinic acid belongs likewife to this clafs.

D. The *laft* clafs confifts of acids, the radicals of which, are compofed, each at leaft of three different fubftances. Such are the animal acids, which have for their radicals, combinations of carbone, hydrogene, and azote.

XVI. Not only are thefe feveral claffes of acids, diftinguifhed by general characteriftics, marking each clafs : But even each particular acid has its peculiar properties, by which its character is difcriminated from the characters of all other acids. Thefe properties may even be expreffed by words and phrafes, not lefs fimple and eafy than thofe which Linnæus

taught

taught naturalifts to employ. A fketch of this mode of ex-
preffing thefe properties, follows below.

XVII. The acids with fimple and known radicals, are all
decompofable by combuftible bodies, which they burn with
more or lefs activity; and are thus reduced to their radicals.
By this decompofition was the nature of the radicals firft dif-
covered. Thefe acids may be alfo compofed anew, by uniting
oxigene with their radicals.

The acids, whofe radicals are unknown, but from ftrong
analogies, fufpected to be fimple; have no other claffific cha-
racter, but that of being indecompofable by combuftible bodies,
and not to be formed by art.

The vegetable acids, with binary radicals, are characterifti-
cally diftinguifhed; 1. By being all decompofable by a ftrong
heat, and by the addition of a due quantity of oxigene. 2. By
affording, when they are thus decompofed, water and carbonic
acid; which are formed by the preparation of their hydro-
gene and carbone, and by the union of each of thefe bodies,
feparately, with oxigene: 3. By their flow, fpontaneous de-
compofition, when they are diffolved in water, and expofed to
a temperature above $54\frac{1}{2}°$ F.: 4. Becaufe they cannot be de-
compofed by any known combuftible body; fince their radi-
cal is compounded of two fubftances, which are remarkable,
as having the ftrongeft poffible attraction for oxigene: 5. Be-
caufe they are mutually convertible in confequence of
differing from one another, at the firft, in nothing elfe but the
proportion of their principles.

The more compound acids with three or more radicals,
which derive their origin from animal matters; although the
leaft known of all the acids; have alfo fome properties which
may be regarded as their claffific characters. Such are, the
property of yielding ammoniac, when they are decompofed by
fire, and of affording Pruffic acid by a change in the propor-
tion of their principles.

XVIII.

XVIII. To thefe claffific characters, we fhall next add the fpecific characters ; and fhall here endeavour to employ a fyftematic, technical language, fimilar to that of the botanift, and the zoologift.

Acids of the firft clafs, having radicals which are fimple and known.

A. Sulphuric acid ; formed from fulphur and oxigene, by the combuftion of the fulphur ; inodorate, twice as heavy as water, very cauftic, lefs volatile than water; affording fulphureous acid gas and fulphur, by its decompofition with redhot coal, metals, &c.; forming fulphates with the earths, alkalis, and metallic oxides.

B. Sulphureous acid, highly odorate, very volatile, gazeous; deftructive to blue vegetable colours, and fit to cleanfe away fpots made with thefe colours on a white ground; abforbing, by flow degrees, the oxigene from the air, and from various acids or oxides ; forming fulphites with the earthy and alkaline bafes.

C. Nitric acid, liquid, white, cauftic, of a ftrong naufeous fmell ; formed of azote and oxigene ; capable of inflaming fulphur, charcoal, zinc, tin, and oils ; liable to lofe, by the action of combuftible bodies upon it, various proportions of its oxigene, and thus producing nitrous acid, nitrous gas, and nitrous oxide ; deftructive to colours ; poffeffing the power of burning vegetable and animal fubftances, making them yellow, and converting them into acids ; decompofing that ammoniac which is produced by the putrefaction of animal matters; forming nitrates with the earths and alkalis; remaining in an imperfect union with metallic oxides, and having a tendency to acidify them.

D. Nitrous acid, or nitric acid with an inferior proportion of oxigene ; in the form of a gas, red or orange coloured; extremely volatile, difcolouring vegetables, becoming blue and green with water ; communicating a yellow colour to nitric acid, when united with it in various proportions ;

D   yielding

yielding nitrous gas, under the contact of combuſtible bodies; and forming nitrites with the earths and alkalis.

E. Carbonic acid is formed of carbone in the proportion of 0,28 parts, united with 0,72 of oxigene; is a gas heavier than common air, which it diſplaces; fills ſubterraneous cavities; is evolved from liquors in vinous fermentation; extinguiſhes lamps, kills animals, reddens only light blue vegetable colours; produces a precipitate of chalk in lime-water, but again diſſolves the chalk in the water; mineralizes acidulous waters, and enters into combination with barytes, lime, copper, iron, and lead in mines and quarries; forms carbonates with the earths, alkalis, and metallic oxides; is decompoſable only by phoſphorus, and when it is in union with alkaline baſes, particularly with ſoda, in the ſtate of a carbonate.

F. The phoſphoric acid is compoſed of phoſphorus and oxigene, combined by a rapid and entire combuſtion; is liquid, thick, or ſolid, vitrifiable by fire; diſſolves ſilices, whilſt in the act of vitrification; is decompoſable by carbone, by which it is reduced to ſimple phoſphorus; and forms phoſphates with the earths, alkalis, and metallic oxides.

G. Phoſphorous acid differs from the phoſphoric, only in containing leſs oxigene; is volatile, and odorate; detaches oxigene from many other bodies; and forms phoſphites with terrene, alkaline, and metallic baſes.

H. The arſenic acid is formed of the metal called arſenic, in union with oxigene. Combuſtion reduces arſenic only to an oxide; and the nitric, or the oxigenated muriatic acid, is then neceſſary to afford the additional quantity of oxigene requiſite to convert the oxide into acid. The acid thus obtained, is fixed, fuſible into a glaſs, decompoſable by the action of a large quantity of light and caloric, and by many combuſtible bodies; forms arſeniates with earth, alkalis, and metallic oxides. The oxide of arſenic which combines alſo with the

the ſame baſes, may be regarded as a ſort of *arſenious* acid.

I. Tunſtic acid is a compound of the metal of tungſten, with oxigene; exiſts in the form of a white or yellowiſh powder, fixed, infuſible, ſcarcely ſoluble, reducible into tungſten by hydrogene, carbone, &c.; forms the native tunſtate of lime, which is called *Lapis ponderoſus*, and the native tunſtate of iron, or *wolfram* of mineralogiſts.

K. Molybdic acid is a compound of the metal named *molybdena*, with oxigene; is of a harſh taſte; is like the two acids laſt preceding, metallic; exiſts in the form of a white powder; becomes blue by the contact of thoſe bodies which reduce it; and then by the loſs of its oxigene, paſſes back into the ſtate of molybdena.

Acids of the ſecond claſs, of unknown radicals.

XIX. The acids of which the radicals are unknown, but ſuſpected to be ſimple, are three in number; the muriatic acid, the fluoric acid, and the boracic acid.

A. The muriatic acid is a gaſeous or fluid ſubſtance, of a pungent ſmell, unalterable by any known combuſtible body; deprives all combuſtible bodies, particularly metallic oxides, of their oxigene, and is thus changed into *oxigenated muriotic acid.* Oxigenated muriatic acid is remarkable for its greeniſh yellow colour; its power of thickening and conſtricting the organs of animal bodies; its property of deſtroying the colours of vegetable ſubſtances, and of inflaming the moſt part of combuſtible bodies; its capacity to form with potaſh, a ſalt which rapidly kindles hot inflammable matters, and produces the pureſt vital air that is known.

B. The fluoric acid is a gaſeous ſubſtance; forms in the air a very thick white vapour; corrodes glaſs; diſſolves ſilceous earth; and with this earth forms a permanent gas, from which water ſeparates a part of the ſilices.

C. The boracic acid is dry, cryftallized in hexahædral plates, fufible into a glafs, almoft infipid, fcarcely foluble, fufible with filices, very feeble in its affinities, and liable to yield up the terrene and alkaline bafes to almoft any other, acid.

Acids of the third clafs, having binary radicals.

XX. The acids with binary radicals, mixed or compound, belong almoft exclufively to the vegetable kingdom, and are formed by the union of carbonated hydrogene, or hydrogenated carbone, with oxigene in various proportions; which, as was before obferved, accounts for their reciprocal converfion into one another. Thefe acids are confiderably numerous; and their number may probably be augmented by progreffive difcoveries. I have therefore divided them into five genera, diftinguifhed from one another, by generic differences in their formation. The *firft* of thefe genera includes thofe pure acids which are formed in vegetables; comprehending the fuccinic acid, which is evidently of vegetable origin: In this genus, are five fpecies; the fuccinic acid, the citric acid, the gallic acid, the malic acid, the benzoic acid. The *fecond* genus contains thofe vegetable acids, which are fully formed in vegetables, but are at the fame time partly faturated with potafh; they are called acidula; they are two fpecies; the tartareous acidulum, and the oxalic acidulum. In the *third* genus, I rank all acids which are formed by the action of the nitric acid, and the precipitation of its oxigene, upon vegetable fubftances: Of this genus, we know as yet only the dftinct fpecies of the camphoric acid: The oxalic and malic acids indeed, are not unfrequently formed from vegetable matters, treated with nitric acid. In the *fourth* genus, I place thofe acids which are formed in vegetables by treatment with fire; fuch as the pyromucous, the pyro-ligneous, and the pyro-tartareous acids. The *fifth* genus confifts of vegetable acids produced by fermentation; of this

this genus we know none but the acetous fpecies. The fol-
lowing are the fpecific charaƈers of thefe twelve acids.

A. The fuccinc acid is difengaged and fublimated from
heated amber; is of a ftrong bituminous fmell, oleaginous
and inflammable, volatile, cryftallizable into needles ; forms
permanent cryftallizable · falts, particularly with metallic
oxides ; and adheres more tenacioufly to the three earths, than
to the alkalis.

B. The citric acid is cryftallizable into rhomboidal plates;
is not convertible into oxalic acid by the nitric acid ; has a
more powerful affinity with the earths, than with the alkalis;
is readily decompofed in water, or by fire.

C. The gallic acid exifts in abundance in nut-galls ; is cry-
ftallized into fmall grey or yellowifh needles ; is ftiptic ; pro-
duces a black precipitate from folutions of iron ; reduces
metallic oxides which it finds in union with other acids ; is
convertible into oxalic acid by the nitric acid.

D. The malic acid abounds in apples ; is not cryftallizable ;
is convertible into oxalic acid by the nitric acid ; is formed,
at the fame time as the oxalic acid, or even more quickly, in
vegetables treated with nitric acid.

E. The benzoic acid is obtained from benzoin, ftorax, bal-
fam of Peru, vanilla, and cinnamon, by means of heat ; is
cryftallizable into flattened prifms ; has an aromatic fmell
when heated ; is fufible by a gentle heat ; is volatile, inflam-
mable, fcarcely foluble in water ; is foluble, but not decom-
pofable by the nitric acid.

F. The tartareous acidulum, is formed of tartareous acid,
imperfeƈly faturated with potafh ; exifts in wines ; is cry-
ftallizable, and decompofable by fire ; affords a large propor-
tion of carbonic acid and oil, with a plentiful refidue of car-
bonate of potafh ; by diftillation, yields pyro-tartareous acid;
is fcarcely foluble ; is decompofable in water ; forms triple
falts with the alkalis and metallic oxides; becomes highly fo-
luble upon the addition of borax or boracic acid to it. The

D 3 tartareous

tartareous acid obtained from this acidulum, is cryftallizable
into needles interwoven together ; is unalterable in the air,
is highly foluble, affords acidulum, upon receiving the addi-
tion of a fmall portion of potafh ; decompofes fo much of ful-
phate, nitrate, or muriate of potafh, or foda, as may afford
potafh fufficient to reduce the acid to acidulum; is convertible
into oxalic acid by the action of the nitric acid.

G. The oxalic acidulum is formed of oxalic acid partially
faturated with potafh ; is obtained as an extract from falt of
forrel ; is cryftallized in parallelipipeds ; is hardly decompo-
fable by fire ; detaches lime from any other acid ; is precifely
fimilar to the acidulum formed by the nitric acid, when it is
brought into contact with any vegetable matter whatfoever ;
is unalterable by the nitric acid ; is the leaft decompofable,
and the moft oxigenated of all vegetable acids.

H. The camphoric acid is formed by the action of the nitric
acid diftilled upon camphor ; is cryftallizable in parallelipi-
peds ; forms with earths and alkalis, neutral falts that are
highly cryftallizable; does not, like oxalic acid, abftract lime
from all the other acids ; is very little known.

I. The pyro-tartareous acid is a modification of the tarta-
reous acid, produced by fire ; has the fmell and colour of a
burnt body ; is very eafily rarefied ; and bubbles up very
much, under the action of heat ; is not cryftallizable ; forms
with earthy and alkaline bafes, falts different from thofe which
the tartareous acid yields with the fame bafes ; is but little
known.

K. The pyro-mucous acid is formed by the diftillation of
gums, fugar, and fecula ; has a lively agreeable odour of ca-
ramels ; is volatile; colours vegetable and animal matters
with a red hue ; is decompofable by intenfe heat ; is but
little known.

L. The pyro-ligneous acid is obtained from wood by diftil-
lation ; has a pungent, fœtid fmell ; is not cryftallizable ; is
decompofable by a ftrong heat ; is volatile ; forms peculiar

falts with earths, alkalis, and metallic oxides ; has peculiar attractions for thefe bafes ; and as to its other qualities and relations, is not better known than the two fpecies laft preceding.

M. The acetous acid is formed by the fermentation of wine, and is on this account named *Vinegar* ; has an agreeable tafte and fmell ; is liquid, volatile, and decompofable by ardent heat ; is liable to be fuperfaturated with oxigene, when it is diftilled with metallic oxides ; and becomes in confequence of this change acetic acid or *radical* vinegar ; which is much more acrid and more odorate than the acetous acid ; and is alfo inflammable, and mixed with alcohol.

Acids of the fourth clafs, with ternary radicals.

XXI. The acids whofe radicals are ternary compounds; and which have been in general defcribed as confifting of carbone, hydrogene, and azote in union with oxigene, belong chiefly to the animal kingdom. They are ftill lefs known than thofe of the third clafs. But, feeing that they all furnifh ammonia by decompofition with fire, and Pruffic acid by a change in the proportion of their principles ; I am led to obferve, that that the Pruffic acid feems to ftand in the fame relation to this genus of acids, as that of the oxalic acid to the vegetable acids in general. When animal fubftances are by treatment with nitric acid, converted into oxalic acid, there is conftantly formed at the fame time, a portion of Pruffic acid, which is difengaged in vapours.

There are feven known animal acids, which appear to belong all to this genus of compounds ; namely, the lactic acid, the faccho-lactic acid, the febacic acid, the lithic acid, the formic acid, the bombic acid, and the Pruffic acid. Each has its characteriftic properties.

A. The lactic acid is formed by the addition of a fmall portion of acetous acid to milk fpontaneoufly foured ; is not cryftallizable, is foluble in alcohol, yields by diftillation,

an acid analogous to the pyro-tartareous acid; forms deliquescent falts with the terrene and alkaline bases; decompofes alkaline acetites.

B. The faccho-lactic acid is precipitated in a white powder from the oxalic acid formed by fugar of milk and nitric acid; is almoft infipid, and almoft infoluble; is decompofable by fire, and yields by this decompofition, a fublimated falt, having the odour of benzoin, and which forms cryftallizable falts with the alkalis; is very little known.

C. The febacic acid is obtained from greafe by the action of fire; is feparated likewife from greafe by the alkalis and lime, with the help of a ftrong heat; is liquid, white, fuming, very acrid in odour and tafte; forms cryftallizable and fixed falts with earth and alkalis; decompofes muriate of mercury; is decompofable by a ftrong heat.

D. The lithic acid exifts in human urine; forms the ftone in the bladder; is dry, cryftallized in flat needles almoft infipid and infoluble, in part volatile, decompofable by a ftrong heat, yields ammoniacal carbonate and Pruffic acid when heated with fire; forms with nitric acid, a folution of a beautiful red colour; is foluble in cauftic alkali; is precipitated from the urine of perfons under fever, with a reddifh or greyifh colour.

E. Formic acid is extracted from ants or *formicæ* by diftillation, or fqueezing with water; reddens blue-flowers of vegetables, even in the living infect; is evolved in a ftrongly odorate vapour; in its fmell refembles mufk; kills animals in this gazeous form; is fit for the fame domeftic ufes as vinegar; is decompofable by a ftrong heat; attracts oxigene from oxigenated muriatic acid; is often ftronger than the fulphuric acid; forms with alkalis and earths cryftallizable and non-deliquefcent falts.

F. The bombic acid is preferved in a refervoir, fituate near the anus of the chryfalis of the filk-worm; is extracted from this refervoir by compreffion, or by means of alcohol, mingled,

mingled, in the worm with a brown oil and a gum; is liquid, of an amber yellow colour, fpontaneoufly decompofable; yields Pruffic acid by diftillation, and with the nitric acid; is not known in its combinations.

Œ Pruffic acid, which faturates iron, and gives it the colour of Pruffian blue, is at prefent obtained by the diftillation of blood, by the action of the nitric acid upon the albumen, the gluten, or the fibres, &c. of animals; is evolved, while a formation of oxalic acid takes place; is remarkable for a fœtid, noxious fmell, refembling that of bitter almonds; is eafily decompofable by a great heat, and on decompofition, yields ammoniac; is capable of affuming the form of gas; attracts metallic oxides from many of the other acids; may be formed by the union of hydrogene, carbone, azote, and oxigene; is flightly acid in its tafte; and contains, as it fhould feem, but little oxigene.

XXII. From what is here laid down, it follows, that the acids which have been divided into two claffes, as being fimple or compound in their radicals; differ yet more effentially in this; that the acids of the former clafs, are not mutually convertible into one another; becaufe there is a wide difference between the properties of one fimple radical, fuch as fulphur, and thofe of another, as for inftance phofphorus. To effect the mutual converfion of any two acids with fimple bafes, it would be neceffary to begin with converting their radicals into one another; a change which is far from knowing how to accomplifh. The fecond clafs of acids, on the contrary, being in general formed of a bafe compounded of hydrogene, carbone, and azote, and combined with oxigene, appear to differ from one another, only in poffeffing different proportions of the two or three principles in the compofition of their radical; and in the proportion of the oxigene by which the radical is acidified. They have a tendency to experience continual variations in the proportions of their compofition; efpe-

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cially under the influence of change of temperature, moisture,
&c.; and they thus pass spontaneously into different states. Thus,
for instance, by the efforts of vegetation merely, plants come
to contain different acids at different periods in their growth.
Thus, solutions of vegetable acids in water, are altered, suffer
a change of nature, and at last yield all, more or less of car-
bonic acid and water, when they reach the ultimate period of
their decomposition.

XXIII. These truths being clearly comprehended, we can-
not fail to perceive, that there remains yet to be discovered,
not only the nature of several acids, the composition of which
is unknown; but even the existence of perhaps a considerable
number of new acids in plants and animals. For among the
products of those organized beings, of which we have begun
to investigate the principles, we are as yet far from having
exhausted all the possible combinations of carbone, hydrogene,
azote, and oxigene; as a very slight calculation will readily shew.
To this order of researches and discoveries, is to be referred,
the examination of those acids which are said to exist in cork,
in grey pease, and in various vegetable matters, as also in the
clot of the blood—*cruoric acid,* and in the gastric juice, &c.
It will also be perceived, upon inspecting the particulars of the
chapter immediately subsequent, that most metals, when
burnt, appear to assume an acid character, and to act the part
of acids in many combinations. Acid substances, therefore,
seem to be the most numerous of all bodies, and to act the
most important part in all those chemical alterations which
bodies, simple and compound, incessantly undergo.

Application of the above propositions.

The artificial formation of sulphuric acid by the com-
 bustion of sulphur in the great way.

The extraction of colour from white linens and stuffs by
 sulphureous acid.

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The new arts of bleaching, by the oxigenated muriatic acid.

Theory of the *Aqua Regia* of ancient chemifts.

The art of engraving on glafs with the fluoric acid.

Part of the theory of the formation of artificial nitre-works.

The exiftence and formation of the known native acids.

The influence of the acids in mineralization.

The extraction and purification of vegetable acids and acidula.

The fpontaneous formation and deftruction of vegetable acids.

The mutual converfions of thofe acids and acidula into one another by vegetation, fermentation, &c.

C H A P.

CHAP. VIII.

Of the Union of the ACIDS *with the* EARTHS *and* ALKALIS.

I. ALL the acids combine without decompofition, with the alkaline earths, and the alkalis. Thefe combinations have been termed *neutral falts, middle falts, compound falts, fecondary falts.* The two former of thefe names, are not correctly applicable to them, except when they are neither acid nor alkaline; the two latter are more accurate, and more ufeful. All thefe falts are eafily formed by art. Nature exhibits a great number, efpecially of thofe which are formed by acids of fimple radicals. Mineralogy is daily obtaining the knowledge of new falts of, this character, by the analyfis of minerals, which can alone explain their intimate nature.

II. All thefe compound falts require to be diftinguifhed by two names; one expreffing the acid; the other, the terrene or alkaline bafe. The firft of thefe names may have two variations of termination, correfponding to two different ftates of the acid in the compound falt. The termination *ate* may be employed, when the acid is one of thofe which are completely faturated with oxigene, and whofe names end in *ic*; thus the falts compounded with the *nitric* acid, may be called *nitrates.* Words terminating in *ite*, will ferve to diftinguifh the

the prefence of thofe weak acids which are not fully faturated with oxigene; and which when alone have names ending in *ous*; thus *nitrites* are falts compounded with the *nitrous* acid.

III. As there are thirty-four fpecies of known acids, and feven bafes, terrene and alkaline, fufceptible of fuch combination as forms compound falts, the number of thefe compound falts might be ftated at 238. But this enumeration would be far from accurate: 1. For there are but a few acids fufceptible of combination with filices: 2. Becaufe there are other acids, which, on account of their weaknefs, cannot, without undergoing decompofition, enter into union with terrene bafes, or with ammoniac: 3. Becaufe there are various acids capable of combining with the fame bafes in three different ways,—or of three different ftates of faturation with thofe bafes; namely, with excefs of acid, in the exact neutral ftate, and with excefs of bafe. Neither can we exactly determine the number of the terrene and alkaline compound falts; for we are as yet far from having examined thofe combinations fo fully as to know them well, and to be certain whether they may not be fufceptible of various faturations, &c.

IV. As the acids have all different elective attractions or affinities for every different terrene or alkaline bafe; it would be neceffary for us to know all thefe different affinities, in order that we might have a complete hiftory of the compound falts. But only a fmall number of thefe affinities have hitherto been exactly determined: We are too far from poffeffing all the affemblage of facts, neceffary to throw due light upon thefe bodies: We have not as yet thoroughly examined a tenth part of them.

V. To enter regularly upon the hiftory of compound falts, we muft divide them into genera and fpecies; and afcertain their generic and fpecific characters. Of this part of the hiftory of thofe falts, only a flight fketch can be here given; becaufe chemifts have hitherto paid fmall attention to it; although it be of the utmoft importance, to apply the methods of

botany to the enunciation of the chemical properties of thefe
and other bodies.

There are two modes which may be employed for the fy-
ftematic arrangement of the compound falts. Of thefe, one
is founded upon the confideration of the nature of the acids;
the other refers to the nature of the bafes. We cannot as
yet form genera which fhall comprehend all thefe falts, other-
wife than upon the nature of the acids; for the acids alone
can furnifh us with generic characters; the influence of the
bafes upon the properties of thefe compounds, is not yet fo
adequately known, as that we can employ thefe alkaline and
terrene fubftances, as the heads of generic divifions.

VI. We may reckon five and thirty genera of compound
falts, correfponding to the number of the acids. The generic
names are taken from the acids refpectively. The following
are the denominations of the thirty-five genera.

        I. Genus, SULPHATES.
        II. Genus, SULPHITES.
        III. Genus, NITRATES.
        IV. Genus, NITRITES.
        V. Genus, CARBONATES.
        VI. Genus, PHOSPHATES.
        VII. Genus, PHOSPHITES.
        VIII. Genus, ARSENIATES.
        IX. Genus, ARSENITES.
        X. Genus, TUNSTATES.
        XI. Genus, MOLYBDATES.
        XII. Genus, MURIATES.
        XIII. Genus, OXIGENATED MURIATES.
        XIV. Genus, FLUATES.
        XV. Genus, BORATES.
        XVI. Genus, SUCCINATES.
        XVII. Genus, CITRATES.
        XVIII. Genus, GALLATES.

                                  XIX.

XIX. Genus, MALATES.

XX. Genus, BENZOATES.

XXI. Genus, TARTRITES.

XXII. Genus, OXALITES.

XXIII. Genus, CAMPHORATES.

XXIV. Genus, PYROMUCITES.

XXV. Genus, PYROLIGNITES.

XXVI. Genus, PYRO-TARTARITES.

XXVII. Genus, ACETATES.

XXVIII. Genus, ACETITES.

XXIX. Genus, LACTATES.

XXX. Genus, SACCHO-LACTATES.

XXXI. Genus, SEBATES.

XXXII. Genus, LITHIATES.

XXXIII. Genus, FORMIATES.

XXXIV. Genus, BOMBIATES.

XXXV. Genus, PRUSSIATES.

VII. Every one of thefe five and thirty genera of compound falts which are here enumerated, is to be confidered, with regard to its diftinctive characters, or to thofe properties which ferve to diftinguifh it from every other genus, and to afford clear notions of thofe differences by which all the genera are mutually difcriminated. We muft, for this end, chufe out one fingle property if poffible, or at the utmoft, two or three properties, ftrikingly different from one another, in every genus; and thus find the peculiar characters of all the genera. The following is an attempt at this.

I. Genus, SULPHATES; decompofable by charcoal, &c. into fulphures.

II. Genus, SULPHITES; yield, by the contact of almoft any acid, the fmell of burning fulphur with effervefcence.

III. Genus, NITRATES; kindle combuftible bodies, at almoft any temperature; and are almoft all reduced to their bafe by the action of fire.

IV. Genus, NITRITES; decompofable by weak acids which feparate from them a red nitrous vapour.

V. Genus, CARBONATES; in which the characters of the bafes ftill remain more or lefs eminent; and which, with all the acids, exhibit a brifk and difcernible effervefcence, that proceeds till the carbonic acid be wholly difengaged.

VI. Genus, PHOSPHATES; decompofable. mediately or immediately, by charcoal, which feparates the phofphorus.

VII. Genus, PHOSPHITES; all immediately decompofable by charcoal, which feparates the phofphorus; and affording vapours by the contact of the fulphuric acid, &c.

VIII. Genus, ARSENIATES; yield by the contact of burning coals, the odour and the white vapour of arfenic; are not decompofable by acids alone, or without a double affinity.

IX. Genus, ARSENITES; the arfenious acid is feparated and precipitated from their folutions, by the contact of any other acid,—even by that of the arfénic acid.

X. Genus, TUNSTATES; become yellow at the contact of the nitric or the muriatic acid.

XI. Genus, MOLYBDATES; thefe are to be known, as yet, only by their affording molybdic acid, when treated with other acids; and by the peculiar properties of the molybdic acid.

XII. Genus, MURIATES; yield muriatic acid, at the contact of the concentrated fulphuric acid; and oxigenated muriatic acid, by the contact of nitric acid.

XIII. Genus, OXIGENATED MURIATES; kindle all combuftible bodies, at a lower temperature, than do nitrates, with a brifk flame; and after this combuftion, remain in the ftate of fimple muriates.

XIV. Genus, FLUATES; emit, at the contact of concentrated fulphuric acid, a vapour that corrodes glafs.

XV. Genus, BORATES; fufible, with or without the feparation of their bafes; yield by folution, in union with another acid,—boracic acid in foliated cryftals.

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XVI. Genus, SUCCINATES; we cannot diftinguifh and characterife, without firft decompofing them, and obferving their acid; they for the moft part retain a fmell of burnt amber.

XVII. Genus, CITRATES; are not fufficiently known to be difcriminated by generic characters; in order to diftinguifh them, we muft feparate the citric acid by the ufe of the ftrongeft mineral acids.

XVIII. Genus, GALLATES; thefe are all very clearly characterifed by the property which they poffefs, of producing a black precipitate from folutions of iron; and of effecting a partial reduction of the oxides of filver, gold, and mercury, —at the fame time, when they feparate them from their folutions.

XIX. Genus, MALATES; are almoft all deliquefcent; are to be diftinguifhed only by a partial extraction of their acid, by means of mineral acids.

XX. Genus, BENZOATES; their genus may be determined by the fmell which they emit of the benzoic acid; and by their affording this acid, when expofed to the action of other more powerful acids.

XXI. Genus, TARTRITES; we find characters fufficiently ftriking, to diftinguifh thefe falts, in their tendency to form triple falts, and acidula lefs foluble than the pure acid and the neutral falts which that acid forms with the fame bafes.

XXII. Genus, OXALATES; their tendency to form acidula fcarcely foluble; and the property which they poffefs of decompofing all calcareous falts; are fufficient to diftinguifh them.

XXIII. Genus, CAMPHORATES; are too little known, for us to be able to affign them, generic characters; they are to be diftinguifhed by the prefence and the properties of the camphoric acid, partially obtained from them.

-E-   XXIV.

XXIV. Genus, PYROMUCITES; in the same case as the camphorates.

XXV. Genus, PYROLIGNITES; equally unknown.

XXVI. Genus, PYRO-TARTARITES; cannot be characterised.

XXVII. Genus, ACETATES; still but indistinctly discriminated from acetites; yield, when decompofed by mineral acids, a very strong, and a very pungent white vapour.

XXVIII. Genus, ACETITES; all to be diftinguished by their acid, feparated from the bafe by other more powerful acids.

XXIX. Genus, LACTATES; are very little known; diftinguifhable only in their acid, feparated by other acids.

XXX. Genus, SACCHOLACTES; like the lactates, unknown.

XXXI. Genus, SEBATES; affording the white vapour, and the acrid odour of the febacic acid, at the contact of the more powerful mineral acids.

XXXII. Genus, LITHIATES; in their attractions, the feebleft of all acids; decompofable even by carbonic acid.

XXXIII. Genus, FORMIATES; very little known, and only diftinguifhable by their acid.

XXXIV. Genus, BOMBIATES; not better known than the formiates.

XXXV. Genus, PRUSSIATES; clearly characterifed by their power of forming Pruffian blue, with folutions of iron.

VIII. To determine the fpecific characters of nearly 245 fpecies which thefe thirty-five genera contain; they muft be ftudied with deep and affiduous care. In this department, the fcience of chemiftry, is not yet far advanced. Wanting fuch knowledge, let us at leaft endeavour to diftinguifh. the path we muft follow in order to complete the hiftory of thefe compounds, and to fix a proper method of ftudying their properties.

Ever

Every compound falt, terrene or alkaline, exhibits to the obferver, the following particulars.

1. Form, and the varieties of form. Thefe are to be geometrically defcribed. The inclination and the degrees of the angles; the primitive formation of the cryftals; their interior forms; their diffoftion; and the laws of diminution which determine their varieties; ought to be all remarked and expected.

2. Its exiftence in nature or art; the comparifon of the native with the artificial falt.

3. Its tafte.

4. The action of fire upon it; which may be either nothing at all, or fufing, vitrifying, fublimating, decompofing, &c.

5. The action of light.

6. The influence of air, which may be either negative, or fuch as to furnifh or abftract water of cryftallization.

7. Its union with water; the quantity neceffary to its folution, at different temperatures; the caloric then abforbed or difengaged; the cryftallization effected by cooling or evaporation.

8. The attraction of earths, modifying, decompofing, not affecting, or entering into a triple compound with—the falt.

9. The effect of the alkalis upon it, which may be negative, decompofing, or fometimes forming a triple compound.

10. The comparative action of the acids different from that exifting in the compound falt; and this is either fuch as to decompofe, and deftroy the peculiar nature of the falt, or fuch as to produce no effect upon it.

11. The influence of the neutral falts upon it; which is either negative, or tending to form a triple falt by entire combination; or effecting a double decompofition by which the bafes and acids are reciprocally changed; or producing a precipitation in confequence of the attraction of fome of the fubftances for water.

12. The folubility or infolubility of the falt in alc
hol.

13. Its alteration or inalterability by charcoal, decompofir
its acid, or leaving it unaffected.

14. The influence of vegetation and fermentation upon th
falt.

15. Its action on the animal œconomy.

IX. If in the prefent ftate of chemiftry, all thefe inquiri
could be fatisfactorily anfwered; the hiftory of the compoui
falts, terrene and alkaline, would then, not only be con
plete, but would throw great light on many of the phæ
nomena of nature and art, which are, as yet, but little unde
ftood.

X. We are already acquainted with fome faline combin:
tions of an acid with two bafes;—and thefe bafes are mo;
efpecially magnefia and ammoniac. Such compounds are d
nominated triple *falts*. But, there are probably many mo·
of them than we yet fufpect; and thefe demand all the atte
tion of chemifts. The earth expofes both at its furface, ɛ
in its cavities near the furface, various faline compounds ɩ
fering from thofe which art produces,—in that the for
alone exhibit the fimultaneous exiftence of two bafes
even of two acids. Borate of lime, and borate of mag
have been already found cryftallized together in
quartz; fulphate of lime and fluate of lime, in earth of
maroch, and ftone of Eftremadura, &c.

Application of the foregoing propofitions.

The knowledge of native falts.

The cryftallization and purification of ufeful falt:

The phænomena of folutions.

The precipitation and preparation of alumir
nefia, &c.

The attraction of lime, potash, soda, and ammoniac for acids.

The formation of neutral salts in nature.

All the particular facts relative to the manufacture of salts.

The preparation of the nitric, muriatic, boracic, &c. acids.

E 3   C H A P.

OXIDATION and SOLUTION of METALS.

I. IN the fixth chapter preceding, we have confidered me-
tals as combuftible bodies undecompounded or fimple, and cha-
racterifed by their more remarkable properties. But thofe
general facts are not fufficient. The part which metals act
among the phænomena of nature, and in the proceffes of art,
requires us to examine them particularly, and in fuch detail,
that we may rightly eftimate the full extent of their varied
influence.

II. Although metals be capable of mutual combination in
their metallic ftate, as well as of union with fulphur, phof-
phorus, carbone, and with all combuftible matters in general;
yet they are more commonly combined with oxigene, before
entering into combination with any other fubftances: Or, in
other words, in order to enter into moft of the compounds in
which they are known to exift; they muft firft be combined
with oxigene, or reduced to the ftate of burnt bodies. All the
fingular phænomena which the metals exhibit in their combi-
nations, all the changes of form which they undergo; are
owing to their attraction for oxigene, and to the varying pro-
portions in which they poffefs this principle.

III.

III. Although there be many cases in which the metals are susceptible of combination with oxigene; yet these may all be reduced to three general heads. The first is *the contact of air*, assisted by the action of caloric; the second is owing to the *decomposition of water ;* the third, to the *decomposition of acids.* In this threefold point of view, we shall here consider the oxidation and solution of metals.

IV. All metals heated in the air, and raised to a certain temperature, higher or lower, before or after their fusion, are liable to burn with a brisk flame, an ardent heat, and a real deflagration. They then absorb oxigene in a more or less solid state. Such as are oxidated slowly, and without any sensible inflammation; nevertheless disengage light and caloric from vital air ; but in quantities so small, that the light and caloric do not, during their disengagement, become perceptible to our organs.

V. Rise of temperature favours the absorption of oxigene from the atmosphere, by metals ; and renders the combination of this principle with these combustible bodies, more solid than it would otherwise be.

VI. While some metals burn in the air, only at a very high temperature,—such as gold, silver, and platina ; there are others that burn at any temperature, even at the lowest and with the utmost readiness ; such as manganese which is oxidated, and crumbles down into a powder, in the space of a few hours, by the contact of air merely, and this even several degrees under zero. Some metals, such as iron, copper, lead, &c. burn slowly, and in the course of a few months in the air, even cold.

VII. All metals increase in weight during this process, which never takes place without the access of air; and absorb a new principle of oxigene from the atmosphere, without losing any thing of their former substance. The name of *calcination* formerly given to this phænomenon, cannot now be retained, any more than the term *metallic calces.* The words

combustion,

combuſtion, and *oxidation*, are now employed to expreſs this
procefs; as is the phrafe *metallic oxide*, to diſtinguiſh metals
which are burnt in it.

VIII. The colours which metals exhibit, as they burn, or
with which their flame is tinged, appear to owe theirorigin
to the folution of metallic particles in the light that is diſen-
gaged : thus copper affords a green flame, &c. as ... ...

IX. Not only do all metals, compared with one another, in
their combuſtion by the contact of air, abforb different quan-
tities of oxigene, in order to their faturation ; but likewife
each metal confidered by itfelf, abforbs various proportions,
and ſtops at different points of oxidation, according as the de-
grees of its temperature vary. Thus tin, lead, copper,
iron, change their colour, and are ſtudded with the tints of
the rainbow, at the loweſt degrees of heat to which they are
expofed in contact with air : lead firſt becomes a grey oxide,
then a yellow, and at laſt a red oxide ; mercury paſſes from
black to white, from white to yellow, from yellow to red ;
iron at firſt a black oxide, becomes next a green, then a
brown, and at laſt a white oxide ; copper is firſt a brown oxide,
then a blue, and in its laſt degree of oxidation, takes a green
colour.

X. The metals differ all from one another, in their attrac-
tions for oxigene. There are fome, which light, almoſt alone,
and with very little caloric, is able to deprive of their oxi-
gene, fuch as gold, filver, &c. Others require in order to
feparate the oxigene, a great degree of heat, and much light ;
fuch as mercury. Laſtly, moſt metallic oxides do not yield their
oxigene to caloric and light alone, and unaffilled by other mat-
ters. To decompofe thefe laſt oxides, they are heated with
charcoal which deprives them of their oxigene.

XI. In confequence likewife of this diverfity in the attrac-
tions of the metals for oxigene, fome metals will abſtract the
oxigene from the oxides of other metals ; almoſt any other
metal detaches oxigene from gold or filver ; copper detaches

I   it

is from mercury, iron from copper, &c. Thofe attractions are not, as yet, all well known. What we do know of them, indicates the following to be the order of the attractions of thefe feveral metals for oxigene; beginning with that which is the ftrongeft; manganefe, zinc, iron, tin, copper, mercury, filver, gold. . . . .

XII. Several metals decompofe water; and accomplifh this fo much the more fenfibly or rapidly in proportion as their temperature is higher; becaufe then the great quantity of the caloric employed, more powerfully attracts and diffolves the hydrogene. Thus fire decompofes water with great energy, at a white-red heat; but cannot effect the fame decompofition otherwife than very flowly at even the higheft temperature of the atmofphere.

XIII. Iron, zinc, tin, antimony appear to be capable of decompofing water. Probably, manganefe, and even fome other metallic fubftances are equally capable of accomplifhing the fame effects. This decompofition is owing to an attraction in the metal for oxigene, ftronger than that of oxigene for hydrogene; and in confequence, the oxides of thofe metals which do not decompofe water, are liable to be wholly decompofed by hydrogene. But here we muft diftinguifh among the different degrees of oxidation: for oxide of iron highly oxidated, namely to a brown colour, is partly decompofed by hydrogene, and reftored to the ftate of a black oxide; as iron abftracts oxigene from water only till it be oxidated black: Beyond this ftate of oxidation, iron is unable to decompofe water.

XIV. All metals capable of decompofing water, effect this decompofition much more eafily and entirely, when they are aided by the contact of a body that has a great tendency to combine with their oxides. It often happens, even that metals, like other combuftible bodies, which would not alone decompofe water, become capable of effecting this decompofition, in confequence of the prefence of fome other fubftances, which act by a difpofing affinity. Thus the prefence of acids, renders

renders almost all metals capable of effecting the decomposition of water.

XV. Metallic oxides have this peculiar in their combinations, that they seem to perform the functions of alkalis or of terrene and alkaline bases, in respect to the acids; although they be, on the other hand, capable of combining with earths and alkalis, as if they were acids. There are indeed fewer of those oxides that incline to act the part of acids, than of those which are fitter for bases to compound salts; and it is observed, in general, that the oxides to which oxigene adheres the most tenaciously, are those which saturate alkalis in the manner of acids;—such as the oxides of antimony, lead, iron, and manganese. It has been already related in the VI. chapter, that there are three metals actually acidifiable.

XVI. The metals cannot be dissolved by the acids, without being previously oxidated. On this account, metallic oxides soluble in acids, dissolve in them slowly and without effervescence: but metals are not soluble in the same menstruum, without movement and effervescence.

XVII. The effervescence produced by the solution of metals, is owing to this cause, that when they absorb the oxigene, they detach it from a principle which then assumes the form of a gas or elastic fluid. This principle proceeds either from water or acids, according as the one or the other of these is the substance decomposed. Sometimes it originates from both these bodies at once; and then they are both decomposed by the metal together.

XVIII. The sulphuric acid thus decomposed by metals, if it be concentrated, yields sulphureous gas: Nitric acid, upon the same occasion yields nitrous gas.

XIX. The sulphuric acid, diluted in water, greatly promoting the decomposition of the water by metals, yields, in this case, gas hydrogene. Solutions of zinc and iron in the aqueous sulphuric acid, act chiefly in this way. The phos-

phoric acid exhibits with metals, nearly the fame phænomena, as the fulphuric acid.

XX. The nitric acid is not only decompofed by various metals, but even fuffers the water in which it is diluted to be decompofed at the fame time as itfelf. In order to this it is enough, that the metal diffolved in the acid, be extremely greedy of oxigene, as is tin. The hydrogene of the water, in this cafe, combining with the azote of the nitric acid, forms ammoniac; and hence thefe folutions afford no gas, but are found to contain ammoniacal nitrate. From this it may be underftood, how moft folutions of white metals in nitric acid, come to afford vapours of ammoniac, when quicklime is caft into them.

XXI. The muriatic acid not being fufceptible of decompofition by combuftible bodies, can by itfelf diffolve, but few metallic fubftances. It acts only on thofe metals which are fo greedy of oxigene, as to decompofe the water in which it is diluted. While metals are diffolved by the muriatic acid, there is always a confiderable quantity of hydrogenous gas difengaged.

XXII. Not only is the muriatic acid unfufceptible of decompofition by the metals; but it poffeffes likewife the property of abforbing oxigene from almoft all metallic oxides. It paffes upon this into the ftate of oxigenated muriatic acid. To its attraction for oxigene does this metal owe the property it poffeffes of diffolving metallic oxides with facility: and it is on this account employed fuccefsfully to diffolve oxide of iron on which the other acids do not act. If metallic oxides fuperfaturated with oxigene be diffolved in muriatic acid, the acid effervefces; a part of it then paffing into the ftate of oxigenated muriatic acid gas. If thefe oxides be oxigenated only to that degree which is requifite for their combination with the acid, they will then diffolve without emotion, and without effervefcence, as falt or fugar in water.

XXIII.

XXIII. The boracic and fluoric acids combine but weakly with metallic oxides. They are incapable of diffolving pure metals, becaufe they are not decompofable by thefe bodies. Yet with water, they produce the oxidation of thofe metals which have the ftrongeft affinity for oxigene. The fame is the cafe with the carbonic acid, which combines readily with moft metallic oxides, and in nature is often found in union with them.

XXIV. The metallic acids are eafily decompofed by the moft combuftible of the metals. They combine readily with the oxides; and in nature, are often found thus combined.

XXV. The vegetable and animal acids, which have radicals compofed of hydrogene and carbone, are not decompofed by the metals, but render water highly decompofable by thefe bodies; and combine in a ftate of fufficient folidity, with the metallic oxides. Several of them, reduce thefe oxides to the ftate of metals.

XXVI. The metallic oxides cannot combine with acids, or remain in union with them, unlefs in confequence of containing certain determinate proportions of oxigene. Under thefe proportions, the combination cannot take place; if the due proportions be exceeded, the fubftances combined, cannot remain in union.

XXVII. Befide this general truth; there is another of the fame order, which relates to each metal and each acid in particular. And this is, that the acid and metal cannot remain in union, otherwife than within the often ftraitened limits of oxidation. There is a determinate proportion of oxigene in the combination of an acid with a metallic oxide.

XXVIII. It is in virtue of this law, that metallic folutions expofed to the air, yield a precipitate, and become turbid, in proportion as the metallic oxide abforbing oxigene from the atmofphere, becomes gradually infoluble in the acid. This is the ratio of thofe decompofitions which are accomplifhed

plished by the atmofphere, upon moft metallic fulphates and nitrates.

XXIX. Nay it often happens, that metallic oxides diffolved in acids, gradually re-act upon thefe falts, and abftract from them, even in clofe-veffels, and in contact with air, a portion of their oxigene, fo that the oxide is foon feparated from the acid, and is precipitated to the bottom of the folution.

XXX. Heat is fingularly favourable to this fucceffive decompofition of acids by metallic oxides. Thus nitric folutions become turbid, or more and more decompofable, by the action of air and water, if they be at the fame time heated. This is particularly remarkable in the cafe of the nitric folution of mercury.

XXXI. Some metals have fo great a tendency to oxidation by acids, that they can neither remain in union with them, nor yet form permanent folutions. Such are, particularly thofe which poffefs the property of becoming acid or forming oxides fufceptible of combination with alkalis; arfenic, tungften, molybdena, antimony, tin, iron, &c. Solutions of thefe metals, in nitric acid efpecially, are always charged with precipitates, and contain little or no metallic oxide.

XXXII. From thefe facts it appears, that, in order to form metallic falts, the metallic oxides muft remain permanently in union with the acids, without having any tendency to feparation. It is alfo neceffary, that care be taken not to augment their affinity for oxigene; and to avoid bringing this principle into contact with them.

XXXIII. Compound metallic falts always, or almoft always, poffefs an excefs of acid. They are otherwife, all more or lefs acrid and corrofive; which fhews that almoft all metallic oxides have a tendency to become acid.

XXXIV. Thofe properties of metallic falts which it is of confequence for us to know, may be reduced under the following heads. 1. Form and its varieties; 2. Tafte and caufticity, more or lefs confiderable; 3. Alteration by light;

4.

4. Fufion, deficcation, decompofition more or lefs perfect, by caloric; 5. Deliquefcence, efflorefcence, or decompofition, more or lefs entire, by means of air; 6. Solubility in water, hot or cold, decompofition more or lefs thorough, by pure water, &c.; 7. Decompofition by alkalis and earths, the nature of precipitated metallic oxides, the complete precipitation or formation of triple falts, partly alkaline or terrene, and in part metallic; 8. The alteration of precipitated metallic oxides at the moment of their precipitation, either by air, or by the nature of the alkali employed, as in the cafe of ammoniac; 9. Reciprocal alteration by different acids, decompofition or the contrary, attraction of acids by metallic oxides, the changes of oxides which are diftinguifhable by their colours; 10. Alteration by the neutral falts, terrene or alkaline, which exhibit either an union without decompofition, or a double decompofition; 11. The reciprocal action of metallic falts upon one another, which difplays either a fimple union, or a fimple change of bafes by the acids, or a change in the combination of the oxigene by which the two oxides are precipitated;—the one partially *de-oxidated;* the other *fuper-oxidated;—* and fuch for inftance, is that ufeful precipitation of the muriatic folution of gold by the muriatic folution of tin, which furnifhes the *purple precipitate of Caffius;* 12. Union with the terrene or alkaline fulphures, and the formation of the different forts of fulphureous ores.

XXXV. Metallic oxides differ from one another in the degrees of their affinity with acids; fo that fome of them may be employed to decompofe the combinations of others. But above all, the varying affinities of the metals with oxigene, act as the principal caufe of the phænomena of the precipitation of metallic folutions : Thus different metals, while they take away the oxigene from other metals diffolved in acids, caufe thefe laft, to appear again in the metallic form ; as copper, for inftance, does with mercury, mercury with filver, iron with copper, zinc with iron, &c. Sometimes the metals do

not detach all the oxigene from the metallic oxides diffolved in the acids. This happens when the precipitating metals do not require all the oxigene of the metals in folution: Thus tin, when precipitating oxide of gold, does not abforb all the oxigene which that oxide contained, but fuffers the gold to be precipitated in a particular ftate of oxidation. Metallic oxides when they thus fhare the oxigene between them in new proportions, are precipitated with properties that deferve to be better obferved, than they have hitherto been.

Application of the general facts in this chapter.

Preparation of all the metallic oxides ufed in the arts.

Coloured glaffes, enamels.

Metallic falts ufeful in the arts.

Effects of thefe falts in the arts in which they are employed.

Solutions, and partings of metals.

Precipitation of metallic oxides by earths and alkalis.

Thefe applications are in general fo various and fo ufeful, that they cannot be explained in detail, elfewhere than under the particular hiftory of each different metal.

C H A P.

CHAP. X.

FORMATION and NATURE of VEGETABLE MATTERS,

I. THOSE matters which compofe the texture of vege-
tables, differ from mineral fubftances, in being of an order of
compofition which is more complex, and in being all highly
fufceptible of decompofition or analyfis, while none of them is
fufceptible of fynthefis.

II. Only the fubftantial contexture of living vegetables, on-
ly their vegetative organs—can form thofe matters which are
extracted from them; no inftrument of art is capable of imi-
tating thofe compofitions that are continually effected in the
organized frames of plants.

III. Although it be with four or five natural fubftances, ca-
loric, light, water, air, and carbone, extracted from the re-
mains of plants, which have been crumbled down and blended
in the foil; that vegetables elaborate all the materials of
which their contexture is formed; yet, do we find a wonder-
ful variety of properties in thefe materials. We may, how-
ever reduce all thefe properties to a certain number of heads,
under the name of *the immediate principles of plants;* becaufe
thefe principles are obtained by fimple proceffes, almoft entire-
<div align="right">ly</div>

ly mechanical, and by a fort of immediate analyfis that pro-
duces no alteration of their nature.

IV. Thefe matters, being more or lefs compound, are lod-
ged in particular organs, or in diftinct veffels or cells, &c.
Sometimes their feat is in the root or in the ftem, in the bark
and the leaves all together : At other times, on the contrary,
only the flowers, fruits, or feeds, and even fome particular
parts of thefe organs, contain the immediate principles. This
varying fituation of thefe immediate principles, fhews the
differences in the organization of the texture to be the caufe
of that diverfity of nature which each of thefe matters dif-
plays.

V. The different place occupied by each of the different
materials of vegetables, is often fuch as to permit us eafily to
obtain them pure and feparate. Where fuch a diftribution
takes place, it is fufficient to bruife or open the veffels or
cells containing the immediate principles, to open them, or
to fqueeze out the liquid juices. Nature, by the fole force
of vegetation, often prefents this feparation already effected,
on the outfide of plants. Thus manna, gum, refins, &c. flow
fpontaneoufly. Art is often obliged to feparate fome of thefe
materials from the confufion in which they are mingled and
united with various other matters. The means fhe employs
for this, are ufually fimple, and eafily practifed ; fuch as reft,
filtration, preffure, wafhing, diftillation by a gentle heat, none
of which, alters the fubftances fubjected to it.

VI. Among the materials which compofe the frame of ve-
getable bodies ; which are obtained from them by fimple
means that alter not their nature ; and which are either
fluid or folid ; may be reckoned the following fubftances.

1. The extractive matter, or extract.
2. The mucous matter, or mucilage.
3. Sugar.
4. Effential falts.

5. Fixed oil.
6. Volatile oil.
7. Aroma.
8. Camphor.
9. Refin.
10. Balfam.
11. Gum refin.
12. Feculum.
13. Gluten.
14. Colouring matter.
15. Gum elaftic.
16. The ligneous part.

Befide thefe fixteen principles, there is found in the ana lyfis of vegetables, a fubffance refembling the albumen in th animal kingdom. It is probable that there are feveral othe vegetable principles ftill unknown; fuch as the matter whic ferves for tanning hides, &c.

VII. It is proper, that the reader here fully underftan that, when all the facts in the analyfis of vegetables, have bee reduced to general terms or leading refults; there has bee nothing more found in any of all the plants hitherto exa mined, but the foregoing eighteen fubftances. Thefe actuall compofe the contexture and fabric of all known vegetables and when thefe are feparated from any vegetable, that vege table is very accurately analyfed. Yet, we are not to fup pofe, that thefe eighteen immediate materials exift in all th different parts of vegetables, or even in every different veg table. Some plants, out of all their parts, afford not even l many as five or fix of thefe materials; others contain eight o nine of them; fome yield them all. But, fuppofing, that w could mix together, and confound, even chemically, all thof plants which are fubjected to any chemical proceffes; th mixture, however feemingly various, would not exhibit mor than the fixteen or eighteen fubftances above enumerated, a

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the refults of the moft exact and elaborate analyfis. Vegetables may therefore be faid to be formed of thofe immediate materials.

VIII. Each of the materials above mentioned, poffeffes peculiar diftinctive properties, from among which we muft felect thofe which may the beft mark their different characters, and difcriminate them, one from another. It is not impoffible to handle this fubject in the manner of the botanifts; ufing but one characteriftic or fpecific phrafe, to diftinguifh each of the materials of which we fpeak. Although this method have not as yet been either propofed or executed in chemiftry; we fhall endeavour to give a fketch of it in the fubfequent fections; as has been already done in the cafe of the acids, and the compound falts.

Characters of the immediate materials of vegetables.

IX. *Extractive matter* or *extract*, is a dry, brown matter, fomewhat deliquefcent, foluble in water; is obtained from the infpiffated juices of vegetables, from infufions, and from decoctions evaporated; yields by diftillation, an acid, a little ammoniac, and fome oil; abforbs oxigene from the atmofphere, and becomes gradually infoluble, in confequence of this abforption; is erroneoufly regarded as a natural foap; is compounded of carbone, hydrogene, azote, and oxigene, and has always a tendency to abforb more of this laft principle, than it contained in its primitive ftate.

X. *Mucous matter* or *mucilage*, is a glutinous, vifcid, infipid fubftance, which yields pyro-mucous acid by diftillation; is foluble in water cold or hot; does not abforb oxigene from the atmofphere; becomes dry and brittle in the form of gum; exifts in the roots, the young twigs, and the leaves; is obtained by expreffion from the bark of trees; connects their fibres together as they grow.

X.

XI. *Sugar*, is of an agreeable, pungent tafte, cryftallizable, foluble, fermentible, in all refpects very like to mucilage, but differing in its fufceptibility of fermentation, and of form-ing alcohol.   Mucilage and fugar are both compounds of car-bone, hydrogene, and oxigene ; and they differ from extract ; 1. In having a fmaller proportion of hydrogene ;—in confe-quence of which, they do not, like extract, abforb oxigene from the atmofphere : 2. In being deftitute of azote, owing to which, they yield no ammoniac by diftillation.

XII. *Effential falt*, comprehends the vegetable acids which are in general formed of hydrogene and carbone more copi-oufly oxigenated than in the three foregoing ingredients : and in confequence of this, the addition of oxigene to thofe ingre-dients, converts them into acids.   The vegetable acids, in whatever number they may be, appear to differ from one another in nothing, fave the proportions of their three prin-ciples.   They are all decompofable by fire, and fufceptible of mutual converfion into one another ; and in an ultimate ana-lyfis, they are all reducible upon the addition of oxigene, to water and carbnic acid.   (*See* title VII.)

XIII. *Fixed oil*, was formerly named *fat oil;* is thick, mild, inodorous ; burns when volatilized ; forms foaps with the cauftic alkalis ; is mixed with a mucilage which Scheele calls the *mild principle of oils ;* is thickened and concreted by the contact of air, and the abforption of oxigene ; fuffers the fame effects from acids and metallic oxides ; is compound-ed of carbone, hydrogene, and a fmall proportion of oxigene. It differs from the preceding compounds, in poffeffing a larger proportion of hydrogene.   Hence its combuftibility, and ten-dency to change into water and carbonic acid, when it is burnt with a fufficient quantity of air ; as in matches which are hollow, and furrounded on all fides with air ; forming lamps with an interior current of air.

XIV. *Volatile oil*, called alfo *effential oil, and effence,* is acrid, highly odorate, wholly reducible to vapour at the

heat

heat of 212° F.; does not readily combine with alkalis; is inflammable by acids; is infpiffated by oxigene to a refin; burns more rapidly than fixed oil, and affords more water; fuffers an eafier precipitation of its charcoal, which then forms lamp-black.

XV. *Aroma*, otherwife called *fpiritus rector*, is a very volatile principle, reducible to vapour by the heat of the atmofphere, and forming a peculiar atmofphere around plants; diftillation of the plant on a *balneum maria*, affords the aroma together with water; fometimes aroma is of an inflammable nature; it prefents in other inftances, faline properties; it combines with alcohol, fixed oils, vinegar, &c. and in thefe combinations, forms what in pharmacy is called *diftilled waters;* it contributes by its prefence to the quantity of volatile oils, that is obtained from plants, and has fo great a refemblance to thefe oils, that the one has been often miftaken for the ether. The intimate nature of aroma is not yet exactly known. We begin to think, that it may be a peculiar fubftance, a folitary principle difengaged from vegetable matters; while thefe matters themfelves are at the fame time, entirely reduced to vapour.

XVI. *Camphor*, is a matter now known to exift in many vegetables; is to be reckoned one of their immediate principles; is of a concrete and cryftalline form, highly volatile, combuftible with fmoke, foluble in a great quantity of water, in alcohol, and in æther; exifts in many volatile oils; is contained, in purity, in the trunk and leaves of a fort of laurel from which it is ordinarily obtained; is very little known, as to its intimate nature; forms with nitric acid, a new and peculiar acid.

XVII. *Refin*, is a matter, foft or dry, fcarcely odorate, combuftible, foluble in alcohol, but not in water; fcarcely alterable by acids, hardly fufceptible of union with alkalis; is obtained from an infpiffated volatile oil, from which it feems to differ only in poffeffing a larger proportion of oxigene.

<div align="center">F 3</div>

XVIII,

XVIII. *Balſam*, is reſin combined with benzoic acid, more
highly odorate than pure reſin ; is deprived of its concrete
acid by the action of fire and water ; yields this acid to
earths and alkalis ; becomes after the loſs of the acid, not un-
like to reſin.

XIX. *Gum-reſin*, is a concrete juice, partly ſoluble in wa-
ter ; forms with water, a ſort of emulſion as well as with vi-
negar, which has been ſuppoſed to be its univerſal ſolvent ; is
more ſoluble in alcohol ; does not flow naturally, like reſin,
from vegetables, but is obtained from their veſſels bruiſed,
in the form of a white or variouſly coloured juice, of a fœtid
odour, more or leſs reſembling that of garlic.

XX. *Feculum*, is a pulverulent, dry, white, inſipid, com-
buſtible matter ; yields by diſtillation, a large proportion of
pyro-mucous acid ; is ſoluble in boiling water ; forms with
this liquid, a jelly ; is convertible into oxalic and malic acid
by the action of the nitric acid ; exiſts in all the white and
brittle matters of vegetables, particularly in tuberculous
roots, and in the grains of gramineous plants ; forms the baſis
of the nouriſhment of animals ; and is diſpoſed to become
with ſufficient rapidity, a component principle of their
bodies.

XXI. *Gluten*, is a ſubſtance, elaſtic, ductile, ſeemingly fi-
brous or membraneous, inſoluble in water, ſlightly ſoluble in
alcohol ; yields by diſtillation a large proportion of ammo-
niac ; is putrefiable like an animal ſubſtance ; takes like ani-
mal ſubſtances, a yellow colour, upon the contact of nitric
acid ; is convertible by nitric acid into oxalic acid ; and ex-
iſting particularly in the flour of wheat, forms the difference
between this and flour of other grains, by giving to the for-
mer, the property of compoſing a paſte.

XXII. *Colouring matter*, goes always along with the one
or the other of the preceding materials ; appears to vary
in its nature,—being ſometimes ſoluble in water, and ſome-
times ſubject only to the action of alkalis, oils, or alcohol ;

owes its diverſified properties to different quantities of oxigene fixed in it; has an affinity for combination with alumines, oxide of tin, &c. is capable of more or leſs perfect combination with the contexture of bodies animal and vegetable.

XXIII. *Gum-elaſtic*, reſembles gum-reſin; appears to exiſt in many vegetables; is remarkable for the ductility and elaſticity which it retains, when dry; affords ammoniac by diſtillation; diffuſes a fœtid odour when burnt; exiſts at firſt in the form of a white, lacteous fluid, and paſſes into the ſtate of gum elaſtic by abſorbing oxigene from the atmoſphere.

XXIV. *The ligneous part*, or *wood*, a matter that has been hitherto too much neglected by chemiſts, forms the ſolid baſe of all vegetables; but is by much more copious in thoſe which are hard, than in ſuch as are ſoft; has been errpneouſly regarded as an earth; is inſoluble in water; affords by diſtillation that particular acid which is called pyro-ligneous; contains a great quantity of carbone; paſſes into three or four different acid ſtates, by the action of nitric acid; appears to be the laſt product of vegetation.

XXV. From what has been above explained concerning the immediate and known materials of vegetables, it follows; that they are all reducible in a laſt analyſis, to three or four principles, the principles, the primary components of them all; namely, hydrogene, carbone, oxigene, and in ſeveral of the above materials azote; and that thoſe materials differ from one another only in the diverſity of the proportions in which they ſeverally contain the elementary conſtituents. But, if by ſimple calculation, we endeavour to find the number of different compounds that may reſult from ſuch combinations, in all the poſſible proportions of three or four primary principles, we ſhall find, that a much greater number of them may eaſily exiſt. Yet, as every one of the ternary or quaternary compoſitions which form the immediate

materials

materials of vegetables, admits, as it should feem, a certain latitude in the proportions of its principles with which it will ftill retain its general charaſter of extraſtive, mueous, oil, acid, refin, &c. &c.; it is natural to infer, that the various proportions of the elementary principles, comprehended within thofe latitudes, muft determine the vaft, unmeafurable variety of colour, fmell, tafte, and confiftency, which is well known to diftinguifh all the materials of vegetables; and which is univerfally obferved in the component parts of thofe vegetable matters which are in common ufe for human food, clothing, buildings, &c.

XXVI. Upon the fame confideration, it will be eafily conceived, that vegetables muft differ in the nature and fpecific properties of their materials, according to the different periods in the advancement of their vegetation; that they can never remain long in the fame ftate; and that the diverfified fcenes which the periods of germination, foliation, bloffoming, fruſtification, and maturation, the fucceffive æras of vegetable life, exhibit, muft neceffarily be accompanied and difcriminated by internal changes, correfponding to the variation of external appearances. Tafte in all its varieties of modification, fmell which is no lefs variable, and thofe diverfities of contexture and confiftency which diftinguifh the different periods in the progrefs of vegetation, are fo many inconteftible proofs of this.

XXVII. It is a new advantage derived from the improvements of modern chemiftry; that we are now enabled to difcern the nature of the materials of plants, which is more complex than that of mineral fubftances. This acquired knowledge leads us to an eftimate of the changes which vegetable matters fuffer from different chemical agents. We can no longer fay that we are ignorant of the manner in which the deftruſtive agency of fire operates upon vegetable fubftances. From the confiderations here ftated, it appears, that when a vegetable, either entire or in its feparate produſts,

is

is fubmitted to the action of fire ; the caloric tends to reduce thofe complex compounds to compounds of a more fimple character, by combining their principles, by two and two, in proportions widely different from thofe in which they before exifted together. By heating vegetable products gently, we difengage the hydrogene which burns alone, and leaves a large refidue of carbone ; when they are ftrongly heated, the carbone is difengaged together with the hydrogene ; both burn together in the air ; and the only refidue left, is a fmall portion of earth and falts forming vegetable afhes.

XXVIII. All the immediate principles of vegetables, are then reducible in an ultimate analyfis, to three or four primary principles, namely, hydrogene, carbone, oxigene, and a little azote in fome of them : This analyfis correfponds accurately to the manner in which vegetables are nourifhed, grow, fpread out, and preferve their exiftence ; fince we know that nothing but thofe fimple principles is required to fupport vegetation :—We have therefore nothing farther to invefligate, but the manner in which plants appropriate to themfelves thefe elements, and the means by which they combine by their organic functions ;—in order to enable us to form by compofitions, thofe fubflances of which the properties have been explained.

XXIX. There feems to be no doubt but that water affords the hydrogene of vegetables ; that they decompofe water in their leaves, aided by the contact of folar light; that they abforb the hydrogene of the decompofition, which is fixed in them, in the ftate of oil, or extract, or mucilage, &c.; and that they evolve the oxigene, of which a great part is fufed by light and caloric, and difengaged into the ftate of vital air. But, a portion of the oxigene of the water thus decompofed, is at the fame time fixed in the contexture of the vegetable, and is retained there, particularly by the attraction of the carbone.

XXX.

XXX. It is not fo eafy to give an account of the origin of the carbone which exifts in vegetables. Some naturalifts think that vegetables decompofe carbonic acid at the fame time as water, and abforb the carbone. This affertion is without proof; although it has gained new authority fince the dif-covery of the decompofition by phofphorus of the carbonic acid combined with foda. Other chemifts think, that vege-table earth, *humus,* dunghills, and efpecially water from dung-hills afford carbone divided, or even diffolved in water; that plants abforb this principle by their roots, and do not abftract it from carbonic acid. According to this opinion, dung af-fords nothing but carbone; and the water of the dunghill is but a faturated folution of this principle. To thefe data muft the chemical theory of vegetation be confined, until it fhall be enlarged by farther inveftigation and experi-ment.

Application of the general truths in the tenth chapter.

Thefe general truths are applicable to a very great variety of cafes in nature and the arts. They refpect agriculture, rural œconomy, pharmacy, materia medica, and all thofe arts which are employed upon vegetable fubftances. The following are a few of the moft important cafes of their ap-plication.

> Germination.
> The unfolding of the leaves of vegetables.
> The bloffoming of vegetables.
> Fructification.
> The ripening of fruits and grains.
> The fucceffive formation of gum, extract, oil, refin, falts, fugar, colouring matter, wood, in the different periods of the life of a plant.
> The growth of the ligneous fubftance, of the bark, &c.

<div align="right">Pharmaceutical</div>

Pharmaceutical preparations of juices, extracts, essen-
tial salts, mucilages, oils, resins, gum-resins, aromatic
waters, &c.
The arts of the sugar-boiler, the confectioner, the mil-
ler, the baker, the starch-maker, the vine-dresser, the
brewer, the distiller, the varnisher, the dyer, the
paper-maker, the indigo-maker, the colour-man, the
flax-dresser, the oil-man, the soap-boiler, the perfu-
mer, the charcoal-burner, &c.

C H A P.

CHAP. XI.

Of the FORMATION and the NATURE of ANIMAL SUBSTANCES; THEORY of ANIMALIZATION.

IT is a certain truth, that animals cannot support their ex-
iftence, without the ufe of vegetables. In natural hiftory, it
has long been faid, that vegetables are formed from minerals,
animals from vegetables. But if this truth have been long
known ; yet the manner in which thefe bodies are mutually
changed one into another, remains ftill unafcertained. This
however is the grand fubjeﬆ upon which, above all others,
the labours of the chemiﬆ ought to be employed. This pro-
blem once folved, we fhall obtain an exaﬆ knowledge of every
thing refpeﬆing the animal œconomy. Modern difcoveries
afford already a variety of refults which muﬆ be ufeful in
thefe important refearches.

II. The fureﬆ means for refolving this problem, is undoubt-
edly, firﬆ, to difcriminate accurately between the different
animal fubﬆances ; to compare them with the peculiar mat-
ters of the vegetable kingdom ; and carefully to examine the
difference or refemblance fubfiﬆing between the two claffes.
There is no doubt, but that, if thefe differences were once
well known ; we might then difcover the caufes to which
they are owing.

III.

III. Collecting the refults of all the analyfes that have been lately made of the blood and humours, and of the folid parts of the human body which are evidently formed by the concretion of the fluids ; we fhall find the moft ftriking differences between animal and vegetable fubftances, to be the following.

A. The property in animal fubflances of affording ammoniac and fœtid products, when acted upon by fire.

B. Their property of putrefying more eafily, and more rapidly, and of emiting an odour much more noifome.

C. Their yielding much more of gas azote, when acted upon by nitric acid.

D. Their contributing in a fingular manner to the formation of nitric acid.

IV. All thefe differences feem to depend upon the exiftence of a particular principle which is azote, in much greater abundance in animal than in vegetable bodies. It fhould feem then, that the addition of azote to vegetables, might fully affimilate their nature to that of animal matters.

V. It is however to be farther obferved, that to thefe primary and *capital diftinctions* between animal and vegetable fubftances, there are other particular phænomena to be added; the influence of which, although, no doubt fmaller upon the animal compound ; is yet, not to be neglected. Such, among others, is the prefence of the phofphoric acid, and of different phofphates, particularly phofphates of foda, lime, and ammoniac, in animal humours. To thefe falts is owing the peculiar quality, and the almoft incombuftible character of the coal of animal matters.

VI. That particular principle which is fo copious in thefe fubftances, and which efpecially eftablifhes the grand diftinction between them and vegetable fubftances, namely, azote; appears therefore to be the efficient caufe of the properties by which animal matters are diftinguifhed ; and particularly of
that

gans, fuch as man, birds, and quadrupeds have. It likewife explains the origin of fome difeafes of the liver, particularly of biliary ftones or concretions.

XI. The *greafe* or *fat*, is a fort of oleaginous matter formed at the extremities of the arteries, at the fartheft poffible diftance from the centre of animal heat and motion ; forms a fort of refervoir, in which that large quantity of hydrogene is fixed, which the lungs are unable to evacuate ; is an oil combined with a confiderable proportion of oxigene, and containing, befides, febacic acid. To confider fat in this light, is, a point fingularly ftriking in the chemical phyfiology of animals.

XII. *Urine* is an excrementitious fluid, more or lefs coloured, acrid and faline, remarkable for the great quantity of uncombined phofphoric acid, of phofphate of foda, of ammoniac and lime which it contains ; ftill more remarkable for containing a peculiar acid which has not as yet been found in the reft of the animal humours ; and which is now named *lithic acid*; becaufe it forms the bafe of calculi in the reins or bladder, in the difeafe called *lithiafis*.

Some of the moft valuable difcoveries of chemiftry refpect the urine; medicine has ftill difcoveries to make concerning this excrementitious fluid. Confidering it, in the firft inftance, as a lixivium intended by Nature, to convey out of the body, a great quantity of faline matters which would otherwife prove noxious to the vital functions : we are hence led to perceive, in the next place, that, in the urinous evacuation, the proportion of the principles will vary with the ftate of the body, and thus will become a fort of meafure indicating by its varying modifications, the health or ficknefs of the vital frame. Phyficians have already fuccefsfully begun their obfervations upon this matter. The urine is to be regarded as containing always the matter of concretions in the reins or bladder. Thefe concretions require to their formation, nothing but the detention of this matter, a longer time than

Nature has defigned, in its proper organs, or an incipient nodule on which fucceffive concretions may be from time to time depofited. The proportions of the different principles is ufeful, and efpecially the naked acids which it containa, are alfo to be carefully obferved; as is likewife the phofphate of lime fufpended in it; both which vary ftrangely in difeafes of the joints, of the aponeurofes, and of the bones. Of thefe when accurately noted, fkilful obfervers may hereafter make a happy ufe in medicine; deriving from them, new means of knowing the nature of fuch diftempers, of afcertaining their progrefs, and perhaps of accomplifhing their cure.

XIII. We can fay little concerning the other animal fluids, fuch as the humour that is tranfpired from the pores, fweat, the gaftric juice, the ceramen of the ears, the faliva, the humour of the ears, the mucus of the nofe, the feminal fluid, &c. becaufe all thefe fluids have hitherto been but little examined. They have, every one, no doubt, a particular compofition, different in each of them, from all the reft, in various points, efpecially in the proportion of their principles. Some of thefe principles being fomewhat better known by modern experiments, than the reft, exhibit a combination of a particular mucilage with water, pure foda, phofphate of lime, and phofphate of foda. Such are tears, the mucus of the nofe, and the fpermatic juice. Of thefe, the two former poffefs the property of becoming thick by the contact of air, and the abforption of oxigene; which probably conftitutes the maturity of the humours in the brain and lungs in cafes of catarrh. The feminal fluid exhibits the fingular phænomenon of the cryftallization of phofphate of lime, hitherto unknown in other inftances.

XIV. Confidering the whole of thofe folid matters which compofe the varied contextum of the different organs of animals; we may divide the fubftances that form them into three principal genera. The firft of thefe will comprehend the albumen; the fecond the gluten or gelatinous matter;

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the third, the fibrina or fibrous matter. Of thefe bodies two
have already been noticed in the VIII. fection of this chap-
ter, under the article, *Blood.* We fhall here briefly mention
thofe permanent phænomena which are to be confidered as the
characters of each of the genera.

First Genus.

Albumen is concrefcible by heat, by acids, by oxides, and
in general by oxigene whenever it is concrete or nearly con-
crete; is foluble by alkalis; exifts, more or lefs condenfed or
oxigenated, and wrought into confiftency, in the membranes,
the tendons, the griftles, and in general, in all white animal
matters.

Second Genus.

The *gluten*, partakes of the folidity of the former genus in
moft of the white organs; is fufceptible of eafy feparation and
folution by boiling water, to which when cooled, it gives the
form of a jelly. As it forms the bafe, or the larger propor-
tion in all the white organs in general; thofe are fufceptible
of more or lefs perfect folution in boiling water, and form
tranfparent jellies by the refrigeration of their folutions.

Third Genus.

The *fibrina* is infoluble in water at any temperature; is
foluble in acids; contains a large proportion of azote; is con-
denfed, concreted, and organized in mufcular flefh, which may
be regarded as the refervoir of all the fibrina contained in the
blood. Confidering the mufcles as the fecretory organs of
this fibrous matter of the blood; we may examine and ob-
ferve all the modifications of the quantity or proportion in
which it is fixed in thofe organs; and may attend particularly
to that exclufion of it; which they feem to exact in certain
morbific ftates of the body, in old age, &c.

XV. Thefe three matters, albumen, gluten, and fibrina, in
concretions, in combinations of two and two, or three and

three

three together, especially if they be in different proportions, compose all the solids of animal bodies. They are separated from one another by an easy and simple analysis. They form also various animal fluids, particularly albumen. Only, in these fluids, they contain less oxigene, more water, and are united with acids, neutral salts, &c. It is to be observed, that the gluten is as scanty in the fluids, as it is copious in the solids : and seems therefore to owe its gelatinous nature to that elaboration which it undergoes, when passing from a fluid to a solid state. Albumen artificially dissolved by acids, assumes properties analogous to those of the gluten.

XVI. The solid, osseous substance of animals, is of another order of composition. A large quantity of an almost insoluble terrene salt (phosphate of lime) is deposited in the primitive contexture or parenchyma of the bones. This is the whole mystery of the structure and composition of these organs. In consequence of this, bones afford a jelly by decoction in water, and yield by distillation, a large proportion of oil and ammoniac. Bones once well calcined or burnt, are after this, nothing more than calcareous phosphate, mixed with some portions of carbonate, muriate, and phosphate of soda.

XVII. When these preceding animal matters, especially when the white fluids inspissated, or the white organs, are heated with nitric acid ; there is disengaged from them, a quantity, greater or smaller, of gas azote, and of Prussic acid gas; which appears to be nothing else than a combination of azote, hydrogene, and carbone, with a small proportion of oxigene. Of this product, the gluten yields the least ; the albumen, more; the fibrina, the most. In proportion as this new combination of the principles of animal matters, takes place by means of the nitric acid ; those matters seem to return to their original state of vegetable substances ; from which, as has been observed, they differ materially in nothing but in possessing a quantity of azote, in having different proportions of carbone and hydrogene, and in the greater complexity of the number

G 2   of

of the combined materials into which the primary elements are formed in the animal compound. Inftead of being ternary compounds, as vegetables are, animal matters are quaternary compounds, or even more complex. Azote is the fourth primary principle of animal matters, which they poffefs in addition to the hydrogene, carbone, and oxigene of vegetables.

XVIII. Thus the converfion of vegetable matters into animal matters, which confifts merely in the fixation or addition of azote ; is to be confidered as the principal phænomenon of animalization. This alone explains the principal difficulties of that phænomenon : and when the mechanifm provided for the addition of this azote fhall have become fufficiently known; moft of the functions of the animal œconomy, which contribute to, or depend upon it, will then alfo be known.

XIX. What is already known concerning this laft fubject, is limited to the following particulars. It is not fo much by the addition of a new quantity, as by the removal of other principles in confequence of which the proportion of the azote originally prefent, becomes greater, that this phænomenon is accomplifhed. In refpiration, the blood exhales a great quantity of hydrogene and carbone; the laft either fimply diffolved in gas hydrogene, or elfe reduced to carbonic acid in the very act of circulation, and in the vafcular fyftem, as fome modern phyfiologifts have conceived. In the cavities of the *bronchiæ* during the act of refpiration, and by means of this act, the hydrogene forms water which is exhaled in expiration. A portion of the oxigene appears to be at the fame time fixed in the blood in the lungs; and circulating with this fluid through the veffels, it is gradually combined with the carbone, fo as to form that carbonic acid which is difengaged from the venous blood in the breaft. It is eafily conceived, that a large quantity of hydrogene and carbone being thus difengaged by refpiration, the proportion of the azote muft be by the fame act increafed. The invefligation of the mechanifm of the other

functions

functions, will no doubt lead to new difcoveries more import-
ant than thefe which are here detailed. What has been done
within thefe laft few years, naturally leads us to expect, that
much more may within no long time be done. The analogy
of action which has been difcovered to fubfift between dige-
tion, refpiration, the circulation, and tranfpiration, has be-
gun to eftablifh upon new views much more folid than thofe
which were formerly entertained,—a fyftem of animal phy-
fiology that promifes a rich harveft of difcoveries and utilities,
No doubt, by the affiduous inveftigation of the phænomena
of digeftion and of growth in young animals, we fhall at length
fucceed fo far as to erect upon thofe bafes, a ftructure equally
new and folid. Every thing is ready for this grand feries of
refearches : Several philofophers have already entered upon
it: A new ardour fpringing from the new conceptions which
they have formed, ftimulates and encourages thofe who are en-
gaged in this department of phyfics. The path which they
have opened up, cannot fail to conduct them to refults the moft
precife and accurate; exceeding in thefe qualities, all that has
been hitherto advanced concerning the functions which con-
ftitute animal life.

Application of thefe propofitions.

The functions of the animal œconomy ; and particu-
   larly,
Refpiration ;
Digeftion ;
Hematofis, or the formation of blood ;
Tranfpiration ;
The fecretion of the bile ;
Offification and ofteogony ;
Nutrition ;
Maladies arifing from the corruption of the humours,&c.
Animal concretions ;

The

The action of various medicines upon the hum
&c. ;
Those arts which are employed in the treatment
mal matters ; particularly, the arts of the t
the currier, the maker of glues, the maker of
cords ; the arts of extracting oils, and of ma
turing into useful implements, the horns,
hooves, &c. of animals.

C H

CHAP. XII.

Of the SPONTANEOUS DESTRUCTION *of* ANIMAL *and* VEGE-
TABLE MATTERS.

I. WHEN vegetables and animals are deprived of life, or
when their products are abstracted from the individuals to
which they belonged; movements are then excited in them,
which destroy their contexture, and alter their compofition.
These movements form different forts of fermentations. The
purpofe of Nature in exciting them, is evidently to render
more fimple, thofe compounds which are formed by vegeta-
tion and animalization; fo that they may enter readily into
new combinations of different kinds. That matter which has
been for a time employed in forming the bodies of vegetables
and animals, is, after their functions are ended, to pafs through
other combinations, and to enter into the compofition of other
bodies.

II. From this definition of fermentation in general, it ap-
pears, that the fpecies of fermentation muft be as various as
thofe of the animal and vegetable fubftances that are affected by
it. But, of thefe, a number pafs through the fame procefs, while
they are reduced to greater fimplicity of compofition; and in
reference to this, all the variety of fermentations may be reduced

to three leading ſpecies; vinous fermentation, acetous ferm
tation, putrid fermentation.

III. Vinous fermentation, as its name indicates, is
fermentation which produces wine or alcohol.   The
matter ſubject to it; is ſaccharine matter, diluted in a cer
quantity of water, and mixed with ſome third matter, vi
table or animal, extract, ſalt, feculum, &c.; for it is now
tain, that ſugar and water alone are not ſuſceptible of vir
fermentation.   The ſaccharine ſubſtance is ſo copious, an
univerſally diffuſed through all vegetable and even ani
matters; that there is a prodigious number of bodies capabl
affording wine or forming alcohol.   All ſweet and ſaccha
fruits when reduced to a pulp, and particularly their expre
juices, undergo an internal emotion at a temperature not
der 66° F. if they be at the ſame time, in a large quant
and neither too thick, nor too liquid.   Hence that vaſt qu
tity of different wines which we poſſeſs; reckoning with th
the decoctions of germinating grains, in which the ſaccha
part is developed by germination; and even the vinou
quors made with milk, honey, blood, &c.

IV. Vinous fermentation diſcovers itſelf in ſaccharine jui
by an increaſe of their bulk, the formation of a copious f
that covers their ſurface, riſe of temperature, the diſeng
ment of a great deal of carbonic acid, the converſion of a fi
liquor into an acid, hot, and pungent fluid.

V. The cauſe of this fermentation appears to depen
the decompoſition of water, of whoſe oxigene, a large fl
is brought into union with the carbone of the ſugar, whic
burns, and ſo converts it into carbonic acid.   At the f
time, the hydrogene of the water, is brought into contact v
the decarbonated ſugar, and by combination with it, ſo
alcohol.   Alcohol may be defined to be *ſugar, deprived
portion of its carbone, the place of which is ſupplied by a
tain proportion of hydrogene.*   This theory explains both
formation of the carbonic acid which is diſengaged du

vin

vinous fermentation; and the formation of alcohol, with all the properties of this new product.

VI. Pure alcohol is a white liquid, of a strong smell, of an hot and acrid taste, convertible into vapour at the temperature of 176° F. inflammable at any temperature; affords, when burning, a large proportion of water and carbonic acid; diffuses no smoke during its combustion; is miscible in any proportion with water, expelling the air and a portion of caloric, while the combination takes place; dissolves the pure or caustic alkalis; decomposes the acids, and by this decomposition, is itself converted into æther; dissolves deliquescent neutral salts, and many metallic salts; detaches from vegetables their volatile oil, aroma, resin, balsam, a part of their gum-resin, and several colouring matters; is by means of all its properties, useful in many operations of the arts.

VII. The formation of alcohol is effected by the destruction of a principle of vegetables; the saccharine matter suffering upon this occasion, a decomposition by which it is reduced to greater simplicity. Vinous or alcoholic fermentation is therefore a commencement of the destruction of those principles which are formed by vegetation. It may be considered as an interior emotion, designed by Nature, to simplify the order of composition which vegetable substances exhibit.

VIII. Acid or acetous fermentation is the second natural movement by which vegetable compounds are reduced to a more simple state of composition. This fermentation which produces vinegar, can take place only in liquors that have already undergone vinous fermentation. It has been remarked that the contact of air is necessary for the production of vinegar. We have even seen air to be absorbed by wine turning sour; and it appears, that a certain proportion of oxigene from the atmosphere is necessary to the formation of acetous acid.

IX. There, are no doubt, other sorts of fermentation analogous to that by which vinegar is formed; but of such fermentations the products are not yet well known. Such, for-instance,

stance, is that which takes place in water mixed with starc
which is called the starch-maker's four water. Such likewi
is that of soured bread, soured cabbages, and four liquors. A
these changes are to be considered as modes of decompositi(
which serve to simplify the complicated combinations of v(
getables.

X. Lastly, After that the liquids of vegetables, or their f
lids moistened, have passed into the acid state; their decor
position continuing under favourable circumstances; that is
say, in a mild or hot temperature, exposed to the air, or
contact with water; conducts them to a putrefaction l
which they are in the end volatilized, in the form of gas,
to most of their principles. There is disengaged, water, ca
bonic acid, carbonated gas hydrogene, sulphurated gas hydr
gene, volatile oil in vapour, and sometimes, even gas azo
and ammoniac. Nothing remains, after this, but a brown
black residue, known by the name of *mould,* consisting of c(
bone that is somewhat fat and oily, and from which water e
tracts several saline substances, and a small portion of extr(
tive matter.

XI. Nature, when organizing animals, and forming th(
humours and solids by complex compositions; has mingled
their composition a germ of destruction, which unfolds its
after the death of the individual.

This destruction is effected by that movement which is call
putrefaction. It consists in a sort of fermentation, in a fi(
decomposition of those liquid or solid substances in which
takes place. The order of the composition of animal matt(
is more complex than that of vegetables, and renders th(
much more susceptible of putrid decomposition.

XII. Animal matters being compounded of hydrogene, c(
bone, oxigene, and azote; and having often superadded to th(
principles, portions of sulphur, phosphorus, &c.; when t(
are deprived of that motion and continual renovation wh(
constitute animal life; are soon altered by the more fi(
spiritual attractions of their principles, which tend to com(

toget(

together, by two and two. This re-action produces binary compounds, such as carbonic acid, nitric acid, ammoniac, carbonated gas hydrogene; which are by degrees evolved into the atmosphere; and as they are evolved, proportionally diminish the bulk of the animal matters from which they are separated. It is in this manner, and in consequence of natural decompofition; that animal matters are seen to become soft, to change their colour and smell, to lose their structure and form, to diffuse through the atmosphere, vapours and gases which are there diffolved, and are destined to convey into other bodies, particularly into vegetables, the materials necessary to their formation.

XIII. All the phænomena of the putrefaction of animal matter, depend upon the mechanism which has been explained. The union of hydrogene and azote produces ammoniac; which has been regarded as the principal product of putrefaction. The combination of carbone with oxigene accounts for the formation and difengagement of carbonic acid; in which all the mysteries of putrefaction were fuppofed to confift, about the time of the first difcovery of the gaffes. The nitric acid, to the formation of which, animal matters powerfully contribute in artificial nitre-works,—is produced by the union of azote with oxigene. A certain quantity of gas hydrogene is difengaged, and involves with it fome portions of carbone, fulphur, and even phofphorus. Hence that noifome fmell, which is fo exceedingly various, and hence, perhaps, the phofphorefcence of all putrefying animal fubftances.

XIV. When all these volatile principles are combined two and two together, and difperfed through the atmosphere, there remains no refidue, but a portion of carbone, united or mixed with fixed faline fubftances, fuch as phofphate of foda, and phofphate of lime. Thefe refidues form a fort of *mould* that is called *animal earth;* which often retains in it a little fulphurated and carbonated hydrogenous gas, a little fat, and fome extract; and in which vegetables find abundance of thofe

2   principles

principles which are fit for the formation of their materials. Hence is it that this animal reſidue, when the previous putrefaction is entirely paſt, forms an excellent ſpecies of manure.

XV. There is a certain quantity of water neceſſary to this putrid decompoſition of animal matters. It affords the oxigene requiſite to the compoſition of the carbonic acid and nitric acid. It contributes remarkably to excite the putrefactive emotions, by means of the attractions of its oxigene. The hydrogene, too, evolved from the water, muſt doubtleſs contribute greatly to the formation of the ammoniac: for it is a well known fact, that, when animal matters are diluted in a large quantity of water, they afford abundance of ammoniac, during their decompoſition.

XVI. Putrefaction, conſiſting in a ſeries of peculiar attractions, is modified in many different ways by all its exterior circumſtances, ſuch as temperature, the medium in which animal matters are placed, the ſtate of the atmoſphere, as more or leſs ponderous, dry or humid, &c. It is thus that carcaſes buried in the earth, immerſed in water, or ſuſpended in air, undergo a diverſity of changes to which their maſs, their quantity, and the vicinity of other bodies, as well as all the varied properties of the three media here mentioned, continually give new and different forms.

XVII. Proofs of the truth of this aſſertion, occur in what happens to dead bodies, interred either ſeparately, each by itſelf,—or in heaps together. The former being ſurrounded by a great quantity of earth, are ſoon deſtroyed by putrefaction, the aëriform or liquid products of which are abſorbed by the ſurrounding earth, or by the atmoſphere. Bodies buried in heaps together, not having around them the ſame ſort of earthen or atmoſpheric receiver, remain long undeſtroyed; their animal matter is entirely converted into ammoniac and concrete oil: and this oil with the volatile alkali, forms that ſaponaceous matter which has been found in the earth of burying grounds, in which there has been too great a number of corpſes depoſited.

XVIII.

XVIII. In water, different phænomena attend the deftruc-
tion of animal matters : As faft as the new products are
formed, the water diffolves, and conveys them into the air.
A continued moifture at a temperature, a few degrees above
32° F. favours the putrefaction of thefe matters, and their fo-
lution into gas. A dry, hot air, on the contrary, volatilizing
the water, dries and hardens the animal bodies, almoft as well
as the dry burning fand does in Egypt, that land of mum-
mies.

XIX. Although all the circumftances of putrefaction, and
all the varieties, almoft innumerable, of the phænomena which
they exhibit ; have not been as yet either difcovered or de-
fcribed ; it is however acknowledged, that all thofe phæno-
mena muft be limited to the converfion of the more complex
compounds into others of a fimpler compofition ; which Na-
ture then employs in new combinations forming the materials
of other complex bodies. She had only lent them for a time
to animals and vegetables. She carries on a perpetual circu-
lation of compofitions and decompofitions ; which difplay her
power, and evince her fecundity, at the fame time while they
fhew a plan of action, equally grand and fimple in its opera-
tions.

Application of the propofitions in this laft chapter.

Befide all the objects mentioned at the end of the two
chapters immediately foregoing, to which the articles in this
chapter afford almoft direct applications ; the principles, par-
ticularly explained in this chapter, are likewife fufceptible of
thefe following applications.

      The prefervation of all fubftances extracted from vege-
        tables ;

      The different fpontaneous alterations which vegetables
        undergo ; acetous fermentation, vinous fermenta-
        tion, &c.;

The

The products of theſe alterations, often employed in the
    arts ;

The production of ammoniac and nitric acid ;

The influence of putrefaction in the different regions of
    living bodies ;

The infection, and other evils, produced by the vapours
    of putrefied matters ;

The theory of the ſituation and management of hoſpi-
    tals, drains, ſinks, lay-ſtalls, common-ſewers, ceme-
    teries, &c.

ELEMENTS

THE PHILOSOPHY

OF

CHEMISTRY.

CONTENTS

OF THE

PHILOSOPHY OF CHEMISTRY.

ADVERTISEMENT.

ADVERTISEMENT.

SOON after entering upon the ſtudy of chemiſ-
try, I was induced, by the perſuaſion of a
Bookſeller, to undertake a tranſlation of FOUR-
CROY's ELEMENTS OF CHEMISTRY, from the
third edition of the original work, then newly pub-
liſhed. In that edition, the author had, for the
firſt time, adopted the *opinions* and the *language*
of the NEW THEORY, which had been lately ſug-
geſted by the important diſcoveries of the illuſ-
trious and lamented Lavoiſier. The new lan-
guage of that theory was in the tranſlation to be
accommodated to the ſtructure and analogy of the
Engliſh tongue; and other peculiar difficulties al-
ſo concurred, to render the taſk in which I had
engaged, extremely arduous. I acquitted myſelf
of it, as well as I could. My tranſlation has been
called for, ſold, and read; till the edition then
printed, has been exhauſted; and till a *fourth Edi-
tion* of the *Original Work*, with *alterations* and
additions by the *Author*, has been received in this

I, in the mean time, continued to purfue my chemical ftudies, with that fondnefs, which the fublimity of the general truths of this fcience, the endlefs diverfity of the phenomena that fall under its laws, and its unrivalled utility for enlightening the arts of life, are well adapted to excite in every ingenuous mind. With great pleafure, therefore, did I liften to the requeft of the prefent Publifhers, when they informed me of their intention to reprint my tranflation of Fourcroy's work; and defired that I would revife and correct it for the prefs; collating it with the new edition of the *original;* altering what the author had altered; and adding whatever additions he fhould appear to have made. I was pleafed to have a new opportunity prefented to me, of humbly doing fomewhat more to promote the knowledge of a fcience in which I delighted. I was not lefs pleafed with the opportunity of correcting fome *erroneous numbers,* fome *awkward expreffions,* fome *unneceffarily paraphraftic paffages,* and *others* in which an *attempt to concentrate* the meaning of the author, had *produced obfcurity,* in that tranflation of this excellent fyftem of chemiftry, which I was now to revife and improve.

What I thus again undertook, I have executed; and the work is here prefented to the public. I have carefully revifed my former tranflation, and have corrected whatever I found to be inaccurate,

<div align="right">obfcure,</div>

obfcure, or coarfely inelegant in it. I have col-
lated it with the new edition of the original work,
and have adopted all the alterations and additions
of the author. I have even added a confiderable
number of *Notes*, correcting errors, illuftrating ob-
fcurities, or fupplying deficiencies of important
information, in FOURCROY's text.

Thefe NOTES it had been eafy for me to enlarge
to almoft any indefinite bulk and number. But,
I reflected, that notes, however they may variegate
the pages of a book, are too often overlooked, in
the reading, efpecially by the young ftudent; or,
if perufed, ferve too often for no other purpofe in
the perufal, except to diftract the attention of the
reader, and to interrupt to his mind the author's
chain of reafoning or narration. After reading an
elementary treatife, exhibiting rather the whole
fyftem of the general principles of any fcience,
than all the detail of minute facts comprehended
under thofe principles ; let the ftudent no long-
er plod among compilations, but trace the fcience
which he ftudies, through the writings of thofe
authors alone, who have enriched it with original
and uncontroverted theories, or with new obferva-
tions and experiments. It were perhaps defireable,
that even this elaborate and comprehenfive work of
FOURCROY, fhould be condenfed to one half of its
prefent bulk, rather than clogged and burthened
with endlefs additions. I have given fuch a pro-

portion of *notes* as feemed indifpenfibly requifite ;
but none for the fake of ufelefs oftentation.

I have always thought that the phyfical fciences
ought not to rejeƈt the advantages of purity, per-
fpicuity, and precifion of ftyle, any more than the
moral fciences and the fine arts.   It is piteous to
fee, what a Babylonifh jargon the tranflation of
many books of chemiftry, natural hiftory, and
natural philofophy, from foreign tongues, has in-
troduced into the Englifh language.   The techni-
cal phrafeology of every art and fcience *muft* be-
come it, becaufe abfolutely neceffary to its accu-
rate expofition.   But foreign words unneceffari-
ly intermingled with Englifh idioms, and Eng—
lifh words in the conftruƈtion and arrangement
of a foreign language, can never ferve the inte—
refts of fcience, and ought not to be employed in
the enunciation of it.   Chemiftry, fince it has a-
fpired above the laboratory of the alchemift, and
the fhop of the apothecary, ought to be arrayed
in thofe fimple, yet dignified and elegant graces
of writing, which are fuitable to its philofophical
charaƈter. I have therefore laboured at once to make
Fourcroy fpeak pure, perfpicuous, intelligible Eng-
lifh; and to preferve ftriƈtly the propriety, the
peculiar phrafeology of the fcience, and of the
new theory.   How far my endeavours may have
been in this fuccefsful, it is not for me to decide.

In fo extenfive a work, executed in hafte, many little inaccuracies will, no doubt, ftill remain.

A new tranflation of Fourcroy's PHILOSOPHY OF CHEMISTRY is prefixed to the firft volume of this tranflation of the ELEMENTS, &c. It cannot fail to be ufeful as a SYLLABUS of all the general doctrines of the fcience, and as a fort of intro-duction to the larger work.

R. HERON,

b 3

NO fcience was ever more generally or
gerly cultivated than chemiftry has
ring thefe laft twelve or fifteen years: No fci
made fuch rapid progrefs in fo fhort a time
circumftances render a fourth edition of this
ceffary. The fecond edition having been al
tirely fold off in the fpace of eighteen mont
confequently lefs time for improving it in a
tion, than I had for improving the firft in it.
edition, therefore, the work was enlarged o
one additional volume: but in the fecond
been added. Every elementary work, as
through fucceffive editions, muft at length
period at which the judgement of the learned
cerning, will declare farther additions unneceff
after which, review and careful corrections w
only proper means of improving it. I am of
that in the third edition my work reached tha
An account of the new difcoveries fince the y
would not have added greatly to the bulk of
lumes: But by the advice of fome judicious

and in confequence of underftanding that beginners found fome difficulties in the perufal of this work, I was induced to alter and enlarge fome chapters in the hiftory of faline matters, of fome of the metals, and of feveral of the immediate principles of vegetable and animal bodies. The additions made, in this *fourth edition*, to the contents of the third, are fo few, as, all together, to enlarge the work but by a few pages in the compafs of the whole five volumes.

When I compofed, in the years 1780 and 1781, an abftract of the fundamental facts of this fcience, to ferve as a fyllabus to my lectures; I followed the fame plan which I had before adopted in my lectures, and of which fome years' experience had taught me the advantages. The unexpected fuccefs of that work induced me to follow the fame plan in the fecond edition, publifhed about feven years fince. The encouragement which the fecond and third editions have received from the proficients in chemiftry and the friends of fcience; and the preference which the rapid fale and the various tranflations authorize me to fay, has been given to my work as an elementary book on chemiftry through all Europe; induce me ftill to adhere to the fame plan which was laid down in the firft edition. To alter my arrangement would have been in fome meafure to form a new work : yet I know not but it *might* be altered without any impropriety. Perhaps, the more correct knowledge which has been gained fince the publication of my firft edition ; the more conclufive reafonings; and the more accurate and numerous experiments with which chemiftry has, fince that time, been enriched; would render it advantageous to arrange the

elements of the fcience in an order fomewhat different:
To place, for inftance, the hiftory of all combuftible
bodies, fulphur, coal, metals, &c. before that of acids;
moft of which falts are either burnt bodies, or com-
pounds of combuftible bodies. This would be to pro-
ceed from fimple to compound : the acids of one king-
dom would not then be feparated from thofe of the
other two kingdoms : only the differences between the
principles of organic bodies and thofe of minerals,
would be treated of in diftinct chapters. I have mark-
ed out a fketch of this method in my Treatife on the
Elements of Chemiftry, intended for the ufe of the la-
dies, and the pupils of the Royal Veterinarian School *.

But although, in the prefent ftate of chemiftry, this
laft mentioned arrangement of its elements may be pre-
ferable; yet that which I at firft adopted, and ftill ad-
here to, is not without its advantages. It requires fome-
what more particular attention from the ftudent : but
even in this inftance, it is peculiarly favourable to his
improvement. It exhibits the fame facts in two diffe-
rent lights; it recals the mind a fecond time to truths,
which have been already fubmitted to its view; and
thus impreffes more diftinct ideas of the different phe-
nomena, and of their mutual relations.

With refpect to the theory laid down in thefe ele-
ments, the third edition was effentially different from
the two former editions. In them, I appeared only as
the hiftorian of the different opinions which had pre-
vailed among chemifts. But, in the third edition, though
                                                                    I

* School for the Medicine of Animals, which was eftablifhed at
Alfort, near Paris.

I ftill maintained the fame impartiality, and gave an ac-
count of the principal theories which have been propo-
fed; yet I efpoufed a fide, and declared myfelf an en-
tire convert to that doctrine which has received from
fome philofophers the name of *pneumatic* or *antiphlo-
giftic*. In this fourth edition, my opinion is ftill more
ftrongly expreffed in favour of the *pneumatic theory;*
becaufe I am ftill more entirely convinced of its truth.
I flatter myfelf, that every unprejudiced perfon who
fhall carefully perufe thefe elements, will find that this
theory differs effentially from all others that have been
hitherto propofed; as it takes nothing upon fuppofition,
admits no hypothetic principle, and confifts only in a
fair detail of facts. I may even venture to fay, that thofe
philofophers who have not yet adopted this doctrine;
particularly thofe who have combated it in fome inftan-
ces with rather too much warmth, have not fully com-
prehended our meaning. They do not fee that the
ground of our opinions, the foundation on which our
principles ftand, is totally different from thofe of other
theories which occur in the ftudy of phyfics. We on-
ly deduce plain inferences from a great variety of facts:
we admit nothing not demonftrated by experiments:
and as we reject every hypothefis, we cannot poffibly
commit fuch blunders as thofe into which the authors
of all former fyftems of phyfics have fallen. Either I,
and thofe other modern chemifts who have produced
fo many ingenious difcoveries, are grofsly miftaken;
or the rifing generation of ftudents, who are taught to
reafon in a very different manner from their predecef-
fors, will renounce, as we have prefumed to do, the
hypothefes which have been fo much agitated in the
fchools,

fchools, and will confine themfelves to the refults of
fair experiments.

The modern *theory of chemiftry*, which is denomina-
ted the *pneumatic*, and which denies the exiftence of
phlogifton, is daily gaining new converts; and is al-
ready fo generally received, that three fourths of the
ftudents, and efpecially of the teachers of chemiftry,
may now be reckoned among its adherents.   The two
moft eminent chemifts in Europe, Dr. BLACK, and
Mr. KIRWAN, after examining, with the utmoft care,
the new principles of the French chemift, and after
contending againft them for the fpace of ten years;
have, at laft, with the candour becoming men of real
genius and enlarged minds, frankly adopted them.
" At laft," writes Mr. Kirwan to M. Berthollet, in a
letter dated on the 26th of January laft, " I lay down
" my arms, and abandon the caufe of phlogifton. I
" clearly fee, that there is no unequivocal experiment
" to prove the production of fixed air from pure in-
" flammable air. This being fo, it is impoffible to
" maintain the doctrine of phlogifton with refpect to
" metals, fulphur, &c. Without decifive experiments
" we cannot form a fyftem, in oppofition to pofitive
" facts. I fhall myfelf compofe a refutation of my
" own effay on phlogifton."

Dr. BLACK thus expreffes himfelf, in a letter to
M. Lavoifier:

" You have been informed of my endeavouring to
" explain to my pupils the facts and principles of the
" new fyftem which you have been fo fortunate as to
" difcover, and which I begin to recommend, as be-
" ing more fimple, more uniform, and more confiftent

" with facts, than the old theory. And how could I
" do otherwife? The many fkillful experiments which
" you have made in the great way, have been profe-
" cuted through all their changing phenomena with
" fuch affiduous care, and fuch fcrupulous attention,
" that nothing can be more fatisfactory than the proofs
" to which they have conducted you. The fyftem
" which you have founded upon your facts, is fo clofe-
" ly connected with them, fo fimple, and fo eafily
" intelligible, that it muft daily obtain increafing ap-
" probation; and cannot fail to be adopted by a great
" many chemifts who have been long accuftomed to
" the old fyftem. You, muft not hope to convince
" every perfon. You well know, that habit enflaves
" the minds of moft men, and makes them believe
" and reverence the greateft abfurdities. I muft con-
" fefs to you, I myfelf have felt its influence. Hav-
" ing been accuftomed for thirty years to believe and
" teach the doctrine of phlogifton, as it was under-
" ftood before the difcovery of your fyftem; I long
" felt a degree of diflike to the new fyftem, which re-
" prefented that as an abfurdity, which I had regard-
" ed as fcientific truth. But that diflike, as it arofe
" only from the force of habit, has been gradually di-
" minifhed and overcome by the clearnefs of your de-
" monftration, and the folidity of your plan. Al-
" though there be ftill fome particular facts of which
" the explanation feems difficult, and fcarce fatisfacto-
" ry ; I am, however, convinced, that your doctrine
" is infinitely better founded than the old theory ; and,
" in this refpect, cannot fuffer by a comparifon with it.
" But, if the power of habit ftill hinder fome old che-
                                        " mifts

" mifts from approving your ideas; the *young* cannot
" be *influenced* by the fame circumftance: they will
" univerfally rank themfelves on your fide. We have
" experience of this in our Univerfity, in which ftu-
" dents enjoy the fulleft liberty in the choice of their
" fcientific opinions. They, in general, embrace your
" fyftem, and begin to ufe the new nomenclature."

It cannot be faid, then, that the antiphlogiftic doc-
trine has not gained many partizans; fince it has been
adopted by the greater number of the moft celebrated
natural philofophers and profeffors of chemiftry in Eu-
rope; fince almoft all French chemifts teach it in their
lectures; and fince, in oppofition to twelve or fifteen
chemifts, in all Europe, who ftill refufe to admit this
doctrine, there are more than fifty eminent profeffors,
and votaries of phyfical fcience, who make it the bafis
of their writings and lectures. How indeed fhould a
fyftem of doctrine fail to ftrike all found and able minds
with its beauty and luftre,—which admits no hypo—
thefis,—infifts upon nothing but the refults of facts,——
explains moft of the phenomena of nature and art,
with a fimplicity and a facility which were unknown
before in phyfical fcience? How fhould experiments
fo carefully performed, and fo accurate, or a logic fo
cogent and rational, fail to perfuade every unprejudi-
ced mind? Let the hiftory of modern chemiftry be
candidly ftudied; let thofe works be read with deep
attention, and all thofe differtations, which have been
written within thefe ten years againft the antiphlogiftic
doctrine; and it will foon be difcerned, that thofe che-
mifts who ftill combat this doctrine, may be divided
into two claffes. Of thefe, *one* part do not underftand

even the bafes of this doctrine, and appear to be ftran-
gers to the train of experiments on which it is found-
ed *. The prejudices of fuch men are not to be over-
come, or convinced : the long-formed habit of imper-
fect and inaccurate proceffes, and the ftrength of old
opinions, abfolutely unfit them for new, general con-
ceptions. The *other* clafs may be faid to be under the
influence of a party fpirit, and are more formidable.
They are acquainted with our modern experiments;
they fay, that they have repeated them; they have
themfelves made difcoveries in this new chemiftry :
<div align="right">Yet,</div>

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* M. Baumé has publifhed, at the end of the new edition of his Ele-
ments of Pharmacy, an appendix, exprefsly intended to make an open
declaration againft the new doctrine, to deny the compofition of wa-
ter, and to decry the new nomenclature. It is unlucky for him, that
every line in his book fhews him not to have comprehended this doc-
trine; to calumniate without underftanding it ; to have repeated none
of the experiments upon which it is founded, with fufficient accuracy;
and to be altogether a ftranger to the fpirit of modern phyfics. Works,
whofe authors thus betray their own ignorance, cannot deferve repu-
tation. Nor have we forgotten the unlucky fate of thofe experiments
and opinions of M. Baumé, which reprefented filicea as convertible
into argill by fufion with alkalis ; or thofe which held forth a pretend-
ed production of boracic acid from fat and argill; or thofe concerning
the fpontaneous irreductibility of the *Perfian precipitate;* the prepara-
tion of æthers, Starkey's foap, metallic falts, with excefs of bafe, ful-
phuric falts with excefs of acid, &c. &c.

It is more furprifing that fuch warm objections fhould have been
made to the pneumatic theory by M. Monnet, who performed many
valuable fervices to chemical fcience, before the difcovery of the gaffes.
Without having thoroughly ftudied, as it fhould feem, the modern
doctrine; without having fufficiently acquainted himfelf with the new
experiments and proceffes which it has employed; he, with great heat,

<div align="right">feta</div>

Yet, they attack the antiphlogiftic theory with arms feemingly ftronger than thofe of the former clafs. The only difference between them and the antiphlogiftians, confifts in their logic and mode of reafoning. Inftead of taking the fhorteft and moft direct way to arrive at the end propofed, they take a long, circuitous progrefs. What proves them not to be in the true road, is, that every one of thefe phlogiftians forms a theory for himfelf in his own way, which has little or no connexion with any other theory: fo that there are as many
different

fets himfelf in oppofition even to Scheele, to whom we owe many of thofe difcoveries, which other chemifts have fince confirmed; he talks of the oxalic acid, the oxigenated muriatic acid, the arfenic acid, as if he had never feen any of thefe acids, as if he had never obtained them in any of his proceffes. He confidently pronounces, that no fuch acids exifts; that the pneumatic chemifts are all miftaken; and that their fyftem is not tenable. Yet, on reading his differtation againft the pneumatic chemiftry, which is inferted in the fourth volume of the Memoirs of the Academy of Turin, it is eafy to fee that he has not fully comprehended the fyftem of the modern chemifts; and, what is more inconceivable, that he has not performed any of his experiments with that accuracy, and thofe proceffes which were requifite to procure the refults which he refufes to acknowledge. In a word, with his method of operating, and with that difdain which he fhews for the calculation of the proportions in analyfes, it was impoffible that he fhould rightly appreciate the modern difcoveries; and he denies their exiftence, becaufe they have, in fact, to him no exiftence. We would wifh perfons who have ftudied the new chemiftry, to read the differtations here cited. They will foon be convinced of the truth of our affertions, and will perceive the reafons why, notwithftanding fo much oppofition; the modern doctrine daily acquires new partizans, and whence it comes to reckon among its partizans, three-fourths of all that is eminent among the philofophers of Europe.

different phlogiftic theories, as there are philofophers averfe to the antiphlogiftic doctrine.

All the philofophers who now admit the pneumatic doctrine, befide being much more numerous than thofe who oppofe it, have alfo the advantage of being at one among themfelves. This ought to weigh deci-fively with perfons engaged in the ftudy of chemiftry, if they cannot truft to their own judgement, and de-termine for themfelves.

ELEMENTS

OF

NATURAL HISTORY

AND

CHEMISTRY.

PART I.

GENERAL FACTS; *and* INTRODUCTION *to the* WORK.

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CHAP. I.

Definition of Chemiſtry; Chemical Proceſſes; and the Advantages of the Science, &c.

CHEMISTS have not generally agreed concerning the moſt proper definition of chemiſtry. Boerhaave, in his Elements, has ranked it among the arts, or, to ſpeak more accurately, has defined only the practical part of it. Chemiſtry, according to Macquer, is a ſcience, the objeċt of which is to diſcover the nature and properties of all bodies by means of analyſis and ſyntheſis. This definition is indiſputably the beſt that

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has yet been given. But as analyfis and fynthefis can-not be employed with equal fuccefs in invefligating the properties of all natural bodies, it would perhaps be better not to mention them at all when we attempt to define this fcience. The chemift cannot attain the knowledge of the properties of bodies without bringing them into contact; and as all that he can poffibly dif-cover is only the mutual operations of bodies; perhaps the following definition may deferve to be adopted, even in preference to Macquer's: CHEMISTRY IS THAT SCIENCE WHICH EXPLAINS THE INTIMATE MUTUAL AC-TION OF ALL NATURAL BODIES. The facts which we are to relate will illuftrate this definition. In order to difplay the extent of this fcience in an orderly and per-fpicuous manner, we fhall confider the fubjects upon which it is engaged; the means which it employs; the purpofes it purfues; and the advantages which it affords.

§ I. *Concerning the Object, the Methods, and the Inten-tions, of Chemistry.*

THE *fubjects* on which the labours of the chemift are engaged, are all the fubftances that compofe the globe which we inhabit, whether buried in its in-terior parts or found at its furface. Chemiftry is there-fore of equal extent with natural hiftory, and the fame limits are common to both.

Analyfis or decompofition, and *fynthefis* or combina-tion, are the two *proceffes* which chemiftry employs to accomplifh its purpofes. The firft is nothing but the *feparation* of the conftituent parts of a compound fub-
ftance.

ftance. Cinnabar, for inftance, is a compofition of mer-
cury and fulphur; the chemical art analyfes it by fepa-
rating thefe two bodies from one another. Till of late
it was generally thought, and many are ftill of opinion,
that this method is more advantageous in chemical re-
fearches than the other. This opinion had even gained
fuch ground among the learned as to induce feveral of
them to define chemiftry, *The fcience of analyfis.* But no-
thing can be more inconfiftent with the juft idea of de-
compofition. In order to fet this important truth in a pro-
per light, we muft divide analyfis into two kinds; the
true or fimple, and the falfe or complex. The *true analy-
fis* is that by which the component principles of the body
decompofed, are obtained, without fuffering any altera-
tion. The only criterion by which we can diftinguifh
whether this analyfis has taken place, is when, by re-
uniting the fimple fubftances to which the compound
body has been reduced, we can form a new compound
precifely fimilar to the former. Cinnabar will again
furnifh an inftance. When the two fubftances of which
this compofition is formed, namely mercury and fulphur,
are feparated by a chemical procefs, they are found to
be in a ftate of purity fimilar to that which they poffef-
fed before their feparation; for by uniting them we can
form a new body, differing in no refpect from the original
cinnabar. But unfortunately for the fcience, this kind
of analyfis can feldom be effected. Chemifts are not fo
happy as to be able to apply it to many of the bodies on
which they make experiments. The neutral falts, and
a few other mineral fubftances, are the only bodies in
nature fufceptible of this fpecies of decompofition.

The

The *falfe or complex analyfis* is that by means of which a body is refolved into principles different from thofe which appeared to exift in the compofition, and incapable of forming, by their reunion, a body fimilar to that from which they were obtained.

This kind of decompofition takes place in moft of the bodies that are fubject to a chemical analyfis; no other condition being requifite, but that more than two principles enter into the combination to be examined, and that they be united by a certain degree of mutual affinity. Many minerals, and all vegetable and animal fubftances without exception, admit of no other fpecies of analyfis. Thus fugar, diftilled in a retort, affords an acid, an oil, and a carbonaceous refidue; but all attempts to recombine thefe into the fame fubftance from which they were obtained, are uniformly fruitlefs. This kind of analyfis cannot enable us to difcover in what ftate fubftances exifted together in any combination before being feparated; and it therefore affords but little ufeful information, and is not to be trufted without the greateft caution. By trufting too haftily to refults of this kind, chemifts have afforded room for all that cenfure to which their art has been expofed. On this account has chemiftry been accufed of abfolutely deftroying bodies in its attempts to feparate their component parts; and we cannot but acknowledge that the cenfure was for a long time juft: but becoming more circumfpect in proportion to her progrefs, chemiftry now rejects that deceitful analyfis to which fhe formerly had recourfe, and poffeffes the means of examining the properties and diftinguifhing the component principles of bo

dies

dies, without deftroying their nature. She even proceeds farther, and, as we fhall have occafion to mention more particularly when we come to treat of vegetable fub-ftances, eftimates the mutual action of principles, and determines by what caufes they are thus modified and changed.

Syntbefis or compofition, the fecond method of pro-fecuting chemical inquiries, is the formation of a com-pound by the artificial reunion of feveral principles. Its utility, its extent, and the dependance that may be placed on the refults which it affords, render it much more valuable than the other: nay, not even a fingle operation in chemiftry can be conducted without pro-ducing fome new combination. Chemifts appear not to have been fufficiently fenfible of its importance. In fact, as fynthefis is both more frequently employed and more highly ufeful than analyfis, chemiftry might be, with a good deal of propriety, reprefented as the fcience of combination, not of analyfis.

Thefe two methods are fometimes employed fepa-rately, but oftener together. It frequently happens that a true analyfis cannot be effected without the help of fome combination. Falfe analyfes are always ac-companied with new combinations by fynthefis; nay, compofition itfelf often produces a kind of analyfis. The laft of thefe facts, however, has been but lately difcovered. The difcovery of a great number of aeri-form fluids, the exiftence of which was not formerly fo much as fufpected, has fhown that in many operations which were confidered as fimple combinations, an invi-fible elaftic fluid is difengaged with effervefcence, and

either efcapes into the atmofphere, or is received in vef-
fels which have been ingenioufly contrived to confine
it. Moft of the combinations of two principles which
were before thought to be fimple fubftances, exhibi
this kind of analyfis. We fhall have occafion to give
frequent inftances of it, when we come to treat of neu
tral falts.

From this fhort account of the analyfis and fynthefi;
of the chemifts, it appears that the whole art of che
miftry confifts in promoting the intimate mutual actioi
of bodies, and in obferving carefully the phenomen:
with which it is attended. It is to be remembered
that Nature herfelf conftantly employs thefe two me
thods, and that from her the chemift firft learned to uf
them. As they depend on the mutual affinities of bo
dies, all that the artift can do is to difpofe thefe in fuc-
a manner that they may act upon each other. Th
young chemift ought carefully to acquaint himfelf wit
thefe important truths : for thefe, with the reft to b
explained in the following chapters of this firft par
form the bafis of the fcience.

Hence it is very eafy to comprehend the final inten
tion of chemiftry. That cannot be merely to difcove
the firft principles of bodies ; for there are many fub-
ftances which cannot be refolved into others more fim-
ple, and whofe component principles are therefore un-
known : yet thefe fubftances, though not fufceptible of
analyfis, admit of combination, and act upon other bo-
dies ; and therefore it appears evident, that the chief
defign of chemiftry is to difcover the mutual actions of
natural bodies, to diftinguifh the order of their combi-
nations

nations, and to eftimate the ftrength of that mutual at-
traction which gives them a tendency to unite and to
remain in union.

§ II. *Concerning the ufeful Purpofes to which Chemiftry*
may be applied.

A PARTICULAR treatife would be neceffary to give a
full view of all the advantages which mankind
derive from this fcience. As the defign of this work
does not admit of our entering minutely into that fub-
ject, we fhall content ourfelves with exhibiting its out-
lines; infifting, however, more particularly on fuch of
them as appear not to have been hitherto confidered
with all the attention which they deferve.

Chemiftry is beneficial to fo many of the arts, that we
may arrange them all under two divifions : the firft,
comprehending all the mechanical arts which depend
on the principles of geometry ; the fecond, including
all thofe which depend upon chemiftry, and therefore
merit the name of chemical arts. Thefe laft are much
more numerous than the other. As they are all found-
ed on chemical phenomena, it is eafy to fee that the
practice of them ought to be regulated by the rules of
chemiftry ; which, by new difcoveries, fimplifies the
proceffes, renders their fuccefs more certain, and even
extends the limits of all the arts dependant upon it.
Thefe are, 1ft, The arts of making bricks, tiles, china,
porcelain, and the other fpecies of earthen ware ; all of
which are preparations of different kinds of clay, baked
into different forms, and expofed to the action of heat

till each may have acquired its proper degree of hard-
neſs. *2dly*, The art of making glaſs; which, by com-
bining a vitrifiable earth with a ſaline ſubſtance, produ-
ces a new body, hard, tranſparent, and almoſt impreg-
nable by the action of the air : A wonderful art, from
which mankind have derived many important advanta-
ges ! *3dly*, The arts of extracting metals from their ores,
of caſting, of purifying, and of alloying them by mixture,
owe alſo their origin and progreſs to chemiſtry, which
is daily throwing new light upon them. *4thly*, The ve-
getable kingdom affords materials to a great number of
arts, which, as well as thoſe above-mentioned, belong
to the province of chemiſtry. The arts of converting
ſaccharine juices, or farinaceous ſubſtances, into vinous
liquors ; of extracting from theſe liquors the ardent ſpi-
rit which they contain; of ſeparating that ſpirit from
the water with which it is at firſt combined ; of uniting
this ardent ſpirit with the aromatic parts of plants ; of
extracting the colouring matter of plants, and applying
it ſo as to tinge ſtuffs ; and, laſtly, the arts of convert-
ing wine into vinegar, and combining vinegar with va-
rious ſubſtances; of ſeparating from grain and other
parts of vegetables that precious ſubſtance of which we
form bread ; and of converting ſo dry and inſipid a bo-
dy as meal, into a light, digeſtible, and pleaſant ſub-
ſtance ; all theſe arts, and many more, which our pre-
ſent limits allow us not to take particular notice of, be-
long to the province of chemiſtry, and are indebted to
this ſcience for their preſent perfection, and in many in-
ſtances for their firſt invention *.

<div align="right">Ic</div>

* *The art of bleaching* is wholly chemical.—H.

It has equal claims to the honour of being the miftrefs or parent of all thofe arts which are employed on animal fubftances. Such is the ufeful art of cookery ; the true end of which is not to flatter the palate, or to va-ry the forms and flavours of meats, for the gratifica-tion of capricious tafte ; but to render aliments eafy of digeftion, by means of boiling, or by applying to them mild and natural feafoning. Hat-making, and the dref-fing, tanning, and currying of leather, belong to the fame clafs of arts. But one of the moft valuable of all the arts, which indeed occupies a middle rank between the arts properly fo called, and the fciences, and to which chemiftry is fingularly ufeful, is pharmacy. E-very perfon concerned in pharmacy needs a very exten-five knowledge of chemiftry, that he may not be igno-rant of thofe alterations to which the bodies he makes ufe of are fubject ; may know how to prevent or cor-rect fuch alterations ; may be enabled to difcover the changes which compound medicines undergo ; and, in a word, may forefee readily the combinations or analy-fes that may be produced by the mixture of any fimple drugs. Every impartial perfon muft agree, that to ac-quire a competent fkill in pharmacy, the ftudent ought, after acquainting himfelf with the natural hiftory of the materia medica, to turn his attention to chemiftry, and ftudy it with the moft earneft affiduity. By thefe means only, can pharmacy be practifed on certain principles, fo as to render to mankind thofe important fervices which entitle it to the high rank it holds among the arts *.

A

* It is probable that *agriculture* may be greatly benefited by the
application

A very curſory view of the ſciences will be ſt
to convince us of what important benefits the
derive from chemiſtry.   To natural hiſtory it i
liarly beneficial.   The earlier naturaliſts employ
phyſical properties of colour, form, conſiſtency,
the diſtinguiſhing characteriſtics of minerals : bt
properties being very liable to variation, the b
which ancient philoſophers have ſpoken are no
known, and their diſcoveries are almoſt total
The moderns have become ſenſible, that, in o
obviate this inconvenience ſo fatal to the pro
natural hiſtory, ſome new method muſt be a
Chemical analyſis has been thought the happi
can be employed; and by this method ſuch ļ
has already been made, that minerals are now
ed in claſſes according to the nature and quar
the principles of which they are compoſed.   T
greſs made in this branch of natural hiſtory is
to the labours of Meſſrs Bergman, Bayen, Monn
Wallerius, Cronſtedt, and ſome other naturaliſ
began the arrangement of mineral bodies accor
their chemical properties.   M. Bucquet, in his
courſes of lectures, had improved on the ideas o
two celebrated naturaliſts; and his mode of a
ment was entirely chemical.   M. Sage, who h
lyſed a great number of minerals, has alſo empl
chemical mode of arrangement : and though no (

application of chemiſtry to diſcover the operation of *manures*,
principle of fertility in ſoils.   *Lord Dundonald's* late work,
Kirwan's eſſay in the *Tranſactions* of the *Royal Iriſh Academy;*
aL.e attempts in this way.—H.

has adopted the whole of his theory, yet mineralogy owes to him the higheft obligations; and few in France have purfued the ftudy with greater induftry and fuccefs. M. Daubenton has availed himfelf of the labours of all his cotemporaries and predeceffors; examining them, however, with a degree of caution worthy of the true philofopher, whofe proper object is to difcover truth amid that maze of error and uncertainty, in which, unfortunately for mankind, it is too often concealed. Nothing, then, can be more certain than the utility of chemiftry to natural hiftory; it affords the only means of removing that obfcurity and uncertainty which muft ever attend fimple defcriptions of natural objects. One obfervation of M. Daubenton merits the particular attention of all chemical philofophers: He advifes them to defcribe carefully the fpecimens on which they make their experiments, in order that they may be generally underftood by naturalifts, and may avoid that confufion which, according to this celebrated profeffor, prevails through the works of many modern chemifts. The only means which I have found proper for avoiding that confufion, is, to connect the two fciences in my lectures, by uniting phyfical defcriptions of bodies with an account of their chemical properties.

But the world are not fo generally convinced of the ufefulnefs of chemiftry in medicine. The errors of the chemical phyficians of the laft century, and the indifference of a number of medical practitioners for this fcience, have impreffed many with an unfavourable opinion of it, which time alone can remove. Yet, it would furely be better not to lend an ear to the voice of

prejudice,

prejudice, but to inquire candidly into the caufes o
thofe miftakes which chemifts have committed, and t
confider by what means they may be for the futur
avoided, and the fcience reftored to its juft honour
Though the firft phyficians who cultivated chemiftry
were mifled by a blind enthufiafm; yet from that n
inferences can be drawn applicable to the chemiftry d
the prefent time. The precifion which the moderns
have introduced into every part of experimental philo-
fophy, cannot but remove all the apprehenfions which
might be entertained, if chemiftry were ftill involved
in the fame degree of myftery and obfcurity in which
it was a century ago. If employed with caution, and
with a due regard to the extent of its powers, it cannot
but be highly beneficial to medicine. After thus ac-
knowledging the whims and blunders of chemifts, let
us proceed to juftify the fcience, by examining how far
it is ufeful to every branch of medicine. Let us firft
diftinguifh between the two great departments of this
extenfive fcience, namely, the theory and the practice;
which, however, ought not to be entirely feparated
from each other, as they have been by fome authors.
The ftudy of medicine ought always to begin with the
anatomy of man and the other animals. But the folids
are the only part of the animal frame fubject to the ex-
amination of anatomy; while it is well known to phy-
fiologifts, that the greateft part of animal bodies confifts
of fluids, by the motion of which life is maintained.
Were we then to confine our obfervation to the ftructure
of the veffels, without examining the nature and pro-
perties of the fluids which they contain, we fhould be

acquainted

acquainted with only one part of the animal fyftem. It is the bufinefs of chemiftry to explain to us the qualities of thefe fluids : chemiftry affords the only means by which we can acquire a knowledge of the principles of which they are compofed, and of the changes which they undergo in performing thofe functions by which they contribute to the fupport of life. Without the aid of this fcience, it would be impoffible for us to difcover the mechanifm of the animal functions ; to diftinguifh between the various fluids feparated by the different vifcera; to obferve what alterations thefe fuffer when collected in their feveral refervoirs ; or to underftand how they are affected by heat, cold, or mixture with other fluids, &c. When we are thus far acquainted with the compofition of animal fluids, it will next be proper to examine what variations they are liable to, from differences of fex, age, conftitution, climate, and feafon; and to trace them through the various fpecies of animals. Thus fhall we eftablifh certain points of comparifon, by means of which the limits of fcience may be extended. It is not enough, however, to examine the chemical properties of the animal fluids when the fyftem is in a found ftate : they fhould be obferved with no lefs attention when the body languifhes under difeafe, in order that it may be certainly difcovered what alterations they fuffer in the various diftempers to which the human frame is liable; what part of the humours predominates in putrid, inflammatory, fcorbutic, or fcrophulous diforders; what faline combinations are formed during the progrefs of the diftemper ; what matter extruded from its proper veffels. Such refearches cannot

fa

fail to make phyficians better acquainted with the hif.
tory of pathology. We think it equally neceſſary to
examine the folids by chemical methods, in the found
as well as in the difeafed ſtate of the body; that by
confidering their properties, we may difcover from what
fluid they are produced ; and, this known, may con.
jecture upon good grounds, what folid or fluid has fuf-
fered alteration in any diſtemper. This pofition, which
is here but flightly mentioned, will be more particular.
ly explained in the chapters on Animal Matters.

But chemiſtry is no lefs uſeful to the practice than to
the theory of medicine; nor can it indeed be ufeful to
the one without promoting the other at the fame time.
It will, therefore, be no difficult taſk to ſhow the de-
pendance of the practice upon the ſcience. To begin
with the art of preferving health ; an accurate chemi-
cal knowledge of the various articles of food, and of
the atmofpheric fluid, is neceſſary to enable us to make
a proper choice of air and aliments. By chemiſtry we
learn what quantity of nutritive matter is contained in
every different article of food; in what particular ſtate
that matter exiſts in each of the bodies in which it is
found ; the nature of the feveral fubſtances with which
it may be combined ; and the means of extracting, pu-
rifying, and preparing it in a manner fuitable to the
ſtrength or weaknefs of different ſtomachs. It is the
fame ſcience that explains to us the nature of thofe
fluids which we uſe to drink ; what properties render
water wholefome or noxious, and how to feparate from
it whatever may render it injurious to the animal œco-
nomy ; what are the principles of fermented liquors,
and

and in what proportion thofe are mingled together in the feveral kinds of wine ; as alfo by what proceffes we may diftinguifh whether wine be genuine or adultera-ted. Laftly, by the fame means we learn, what pro-perties render air fit for refpiration ; to what changes this fluid is liable ; and what other fubftances are ca-pable of altering its purity, by entering into combiña-tion with it. Chemiftry likewife fupplies us with the happy means of correcting the qualities of air when noxious, fo as to reftore it to that ftate in which it is proper for refpiration : for the difcovery of which means we are indebted to the induftry of the moderns, as will be fhown in the Hiftory of Air *.

The phyfician ought not to make ufe of medicines unlefs he know their nature ; and this knowledge he muft learn from chemiftry. This has been fo long ge-nerally acknowledged, that the writers of the materia medica arrange medicines by their chemical properties. The uniform experience of all ages has eftablifhed it as a certain truth, that there is a clofe and natural relation between the tafte of bodies and the manner in which they act on the animal œconomy ; fo that by tafting any fubftance we may judge of its medicinal qualities : Bitters are ftomachic ; infipid fubftances, mild and re-laxing; bodies of an agreeable fweet tafte, nutritious ;

acid

* The application of aëriform fluids to the cure, particularly of con-fumption and cancer ; which has been attempted in Britain, by Drs. Beddoes, Ewart, Darwin, and others ; if finally fuccefsful in fuch a number of unequivocal cafes, as may recommend it to the practice of phyficians in general ; will greatly enlarge the range of the utility of chemiftry in medicine.—H.

acid fubftances, active, penetrating, and incifive. Bt
as tafte is undeniably a chemical property, dependin
on the tendency of fubftances to combination, as fha
be elfewhere fhown, we muft confefs ourfelves indebte
to chemiftry for whatever knowledge of the propertic
of bodies we can gain by examining their tafte.   Yet
would be abfurd to fuppofe, with the chemical phyf
cians of the laft century, that the ftomach is a veffel i
which chemical proceffes are carried on, as in a labori
tory.   The inteftines poffefs indeed fenfibility and a pt
culiar motion, which modify the nature and operatio
of fuch medicines as are adminiftered ; but it become
the phyfician to reprefs thofe wild fallies of imaginatio
which lead to ridiculous hypothefes, and to admit onl
fuch facts as are eftablifhed by accurate obfervation. 1
cannot be denied, that, in fome cafes, medicines act i
the firft paffages by means of their chemical propertie
then, indeed, the phyfician may apply his chemica
knowledge.   Long experience has fhown, that in tht
difeafes peculiar to children, the ftomach and inteftine
are coated with a tenacious vifcid matter, which is ma:
nifeftly of an acid nature.   The abforbent earths, and
alkalis adminiftered on fuch occafions, deftroy this acid
by entering into combination with it, and form a neu-
tral purgative falt, which by ftimulating the inteftine,
caufes them to evacuate the noxious matter.   All dif-
eafes that occafion an accumulation of obftructive mat-
ter in the primary paffages, require the phyfician to
poffefs fome chemical knowledge ; as it is certain that
fome fubftances will act with more force than others on
that obftructive matter.   Thus, for inftance, acids may
                                                    be

be adminiftered to remove one kind of obftruction, and
a folution of falts for another.

But the greateft advantage which the practitioner of
medicine can derive from chemiftry, is on thofe alarm-
ing occafions when, by accident or defign, fome of
thofe corrofive fubftances have been fwallowed, which
prove fatal to life by attacking the vifcera, and de-
ftroying their organization. On fuch occafions chemif-
try lends the readieft and moft effectual aid to medi-
cine, by fupplying fubftances which have power to de-
compofe the poifon, and by that means obviate its dire-
ful effects. Navier, a celebrated medical chemift of
Chalons, has publifhed a work, in which he points out
effectual remedies to prevent the deftructive effects of
the poifons of arfenic, corrofive fublimate, verdegris,
or the preparations of lead. Notwithftanding the an-
gry declamations of fome phyficians, who feem defir-
ous of excluding the fciences from the practice of medi-
cine, his work well deferves the gratitude of pofterity.
Not only does chemiftry at prefent enable us to coun-
teract effectually the operation of mineral poifons; but
there is even reafon to hope, that careful inquiries into
the nature of animal and vegetable poifons, may enable
us to difcover fome fubftances capable of divefting them
alfo of their pernicious powers. Opium, and all narco-
tic vegetables, the acid and cauftic juices, fuch as thofe
of fpurge and euphorbium, the noxious plants, parti-
cularly mufhrooms, are all well worthy of the particu-
lar attention of the chemift ; as by his refearches fome
means may poffibly be difcovered which may render
them hereafter lefs dangerous. It is of no lefs impor-
tance to examine the nature of animal poifons. From

the experiments of Margraaf and Fontana we are ;
ready acquainted with the acid of ants : Thouver
has difcovered feveral acrid fubftances in cantharide
Mead has examined the venom of the viper : Fonta
has purfued a train of inveftigation concerning the far
poifon ; and has difcovered, that *lapis caufticus*, inti
duced immediately into the wound made by this re
tile, decompofes the poifon, and prevents its effects.

Did chemiftry even contribute lefs in thefe inftanc
to the benefit of medicine ; yet ftill by fupplying fur
a number of valuable drugs, fhe muft be confeffed·
render fervices of the higheft importance to this ufef
fcience. *Stibiated* tartar, together with the varior
mercurial, antimonial, and martial preparations, whic
are fo often and fo fucceffully prefcribed, when con
fidered as the gifts of chemiftry, muft furely indue
phyficians to efteem the fcience, and to encourage thof
who profecute chemical refearches from a defire to con
tribute to the advancement of medicine. As for my
felf, the natural bent of my genius, no lefs than m;
particular fituation, leads me to cultivate both thel
fciences with the moft earneft wifhes to promote the
improvement. The declamations of thofe, who froi
their ignorance of chemiftry, are induced to reprefer
it as of no utility in medicine, fhall never detach n
from its purfuits. I have engaged with ardour in tl
ftudy of animal chemiftry, and am determined to fo
low the fteps of thofe who have already profecuted
with fo much fuccefs.

To conclude our obfervations on the utility of che
miftry to medicine ; we fhall only add, that a certai
degree of chemical knowledge is abfolutely neceffary 1
                                                    enab;

enable the phyfician to make out a prefcription of any compound medicine, to be prepared by the apothecary. Perfons unfkilled in chemiftry are liable to commit the groffeft blunders daily in making out prefcriptions; to order, for inftance, the compofition of fubftances incapable of fubfifting in union, or which have a mutual tendency to decompofe one another. In the cafe of decompofition, the medicine adminiftered cannot poffibly produce the defired effects. Chemiftry furnifhes the only means to prevent fuch blunders; which are often attended with the moft unhappy confequences. If poffeffed of chemical knowledge, we will never attempt to compound together fubftances incapable of mutual combination; the laws of chemiftry muft always direct us in the preparation of compound medicines. Without a knowledge of chemiftry, the phyfician muft ever be liable to commit numerous blunders; which, though they fhould be followed by no other bad confequences, cannot but expofe him to the contempt of the apothecary; as the practice of the apothecary naturally makes *him* acquainted with many chemical facts.

The ufefulnefs of chemiftry in the arts, and the refemblance of its proceffes to the manipulations of artifts, have caufed it to be confounded fometimes with alchemy, fometimes with pharmacy; though *they* muft be very ignorant indeed, who can thus confound objects fo widely different from one another, and can regard the chemift as a fanciful projector, unweariedly employed in a vain fearch for the philofopher's ftone. Even a very flight attention to the nature and purfuits of chemiftry, may be fufficient to convince any perfon

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that there is a vaſt difference between thoſe purpoſe which the chemiſt purſues in a train of regular connec ted reſearches, and the tranſmutations which the al chemiſt pretends to effect by a ſet of abſurd and deſul tory proceſſes. That miſtake which leads many peopl to regard chemiſtry as the art of preparing drugs is mon excuſable ; it confounds not the chemiſt with the igno rant and inſignificant operators of the Great Work who, as is humorouſly obſerved by Macquer, are the artiſans of an art which has no exiſtence ; but aſſociates him with a claſs of uſeful and reſpectable artiſts, whoſe labours are of high importance to ſociety. Yet as phar. macy is but one branch of chemiſtry, to confine che. miſtry to the making up of medicines, is to entertain a very unjuſt idea of the extent of the ſcience. Pharma. cy, as well as all the other arts dependant on chemiſtry, is guided and aſſiſted in its operations by this ſcience. But chemiſtry, in its nature and objects, is more ſub. lime and extenſive ; it extends its inquiries and induc. tions to the reciprocal action of all the bodies in nature; and thus contributes at the ſame time to the advance. ment of both philoſophy and the arts.

- C H A P.

C H A P. II.

The History of Chemistry.

E student of any science should make himself ac.
uainted at least with the outlines of its history. A
:dge of the leading facts, and of the dates of dif-
discoveries, will be of use to enable him to avoid
ors of those who have preceded him in the same
s, and to direct him to the path which leads to
ement.   But as a very minute detail of the hi-
f chemistry might possibly be considered as an
fary digression from the main object of this trea-
: shall confine ourselves to a view of leading facts,
t entering into particulars.   Whoever is desirous
:r information concerning the rise and progress
mistry, may consult a variety of well-written
which have been published on the subject; par-
y, the Treatise of Olaus Borrichius, *de ortu et*
Tu Chemiæ; the article *Chimie* in the *Dictionnaire*
pedique; the Introduction to Senac's Treatise on
try; Abbé Lenglet du Fresnoy's History of the
tic Philosophy; the first Chapter of Boerhaave's
try; the Discourse perfixed to Macquer's Che-
Dictionary; Bergman's Essay on the History of
try, &c.

ive the reader a brief and methodical account of
grefs of the human mind in the study of chemif-
d of the successive discoveries which have been
1 this science; we shall divide our history into six

I.

*The origin of Chemiſtry among the Egyptians, and i
progreſs among the Greeks.*

THE origin of chemiſtry is hid in the ſame obſcurit
which conceals that of the other arts and ſciences. Tl
patriarch Tubal-Cain, who lived before the flood,
conſidered as the inventor of chemiſtry ; but the onl
part of it known to him was the art of working metal;
he ſeems to have been the ſame with the Vulcan of fi
bulous hiſtory.

We may with more confidence aſcribe the invention
of this ſcience to the ancient Egyptians.   According t
Abbé Lenglet du Freſnoy, Thoth or Athotis, ſurnamer
Hermes or Mercury, is the firſt of this nation of whon
mention is made as being a chemiſt.   He was the ſon c
Mezraim or Oſiris, and the grandſon of Cham.   He be
came king of Thebes.

Siphoas was the next Egyptian monarch, who wi
alſo diſtinguiſhed as a philoſopher.   He lived 800 yea
after Athotis, and 1900 before Jeſus Chriſt.   He is ni
med Hermes, or Mercury Triſmegiſtus, by the Greek;
and is therefore the ſecond Mercury : he is conſideri
as the inventor of natural philoſophy ; he wrote tv
and forty books on the ſubject of philoſophy, the titl
of which have been handed down to us by various h
ſtorians.   None of them ſeems to have treated direct
of chemiſtry ; though from him has the ſcience been i
titled the Hermetic Philoſophy.

We know but little concerning thoſe who cultivate
chemiſtry among the Egyptians ; but the ſcience a

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pears to have made confiderable progrefs among them, for they practifed many of the arts dependant on chemiſtry; particularly the arts of forming imitations of the precious ſtones, of caſting and working metals, of painting upon glafs, &c.: but the chemiſtry of this ancient people has been loſt, as well as their other arts and fciences. The prieſts involved them in myſtery, and concealed them under the veil of hieroglyphics. Alchemiſts have perfuaded themfelves, that fome veſtiges of their pretended art may be traced among the remains of the Egyptian hieroglyphics; and that the temple which the Egyptians dedicated to Vulcan was erected in honour of alchemy.

The Ifraelites acquired a knowledge of chemiſtry from the Egyptians. Mofes is confidered as a chemiſt, on account of his diffolving the golden idol which the people had fet up. It has been thought, and Stahl has even written a differtation to prove, that he rendered the gold foluble in water by means of liver of fulphur. Such a procefs fuppofes a pretty extenfive knowledge of chemiſtry.

Democritus of Abdera, who lived about 500 years before Jefus Chriſt, travelled into Egypt, Chaldea, and Perfia, &c. and is faid to have gained fome ſkill in chemiſtry in the firſt of thefe countries. Though the fon of a man whofe opulence had enabled him to entertain Xerxes and all his attendants, he returned very poor to his native country, where he was kindly received, however, by his brother Damaffus. Retiring to a garden near the walls of the city of Abdera, he employed himfelf in the ſtudy of plants and precious ſtones. Cicero afferts, that Democritus, in order that he might

not be diverted from his ſpeculations by external ob-
jects, deprived himſelf of fight by gazing on the rays of
the ſun reflected from a veſſel of poliſhed copper: But
Plutarch denies this fact. Pliny was ſo amazed at the
knowledge of Democritus, that he conſidered it as quite
.miraculous.

Some authors reckon Cleopatra a chemiſt, beoauſe
ſhe knew how to diſſolve pearls. It is even affirmed,
that the art of chemiſtry being known to all the Egyp-
tian prieſts, continued to be practiſed among that na-
tion till the time when, according to Suidas, Dioclefian
thought to reduce them more eaſily under ſubjection, by
burning their books on chemiſtry.

II.

The Chemiſtry of the Arabians.

AFTER a long ſeries of ages, through which it is im-
poſſible to trace the progreſs of chemiſtry amid the re-
volutions of empire ; this ſcience again appears among
the Arabians, and cultivated ſo ſucceſsfully as to merit
our attention.

Under the dynaſty of the Achemides, or Abaſſides,
the ſciences, which had long been neglected, regained
their former vigour. Almanzor, the ſecond Caliph of
this family, eagerly cultivated aſtronomy. Harum
Rafchid, the fifth Caliph, who was cotemporary with
Charlemagne, cauſed ſeveral books on chemiſtry to be
tranſlated from the Greek into the Arabic.

In the ninth century, Gebber of Thus, in Chorazan,
a province of Perſia, wrote three different treatiſes on
chemiſtry; which contain a number of tolerably good
                                          things.

things. His maſterpiece is entitled, *Summa perfeſtionis magiſterii.* He has written with conſiderable perſpi-cuity on diſtillation, calcination, the reduſtion and the ſolution of metals.

In the tenth century, Rhazes, phyſician to the hoſpi-tal of Bagdad, firſt applied chemiſtry to medicine. Some of his pharmaceutic preſcriptions are ſtill in eſteem.

In the eleventh century, Avicenna, a phyſician, in imi-tation of Rhazes, applied chemiſtry to medicine. His merit raiſed him to the office of Grand-Vizir; but his de-baucheries occaſioned his degradation from that office.

III.

Chemiſtry paſſes from the Eaſt to the Weſt, in the time of the Cruſades : Reign of Alchemy.

THE art of making gold continued long in repute, according to the authors who have written upon it. But the madneſs that gave riſe to it was at its greateſt height between the eleventh and the ſixteenth century. The chemical faſts which had been diſcovered by the Egyptians, collected by the Greeks, and applied to me-dicine by the Arabians, became known to the four na-tions who viſited the eaſt in the Cruſades ; and England, France, Germany, and Italy, ſoon ſwarmed with a ſet of men eager in ſearch of the philoſopher's ſtone. As their labours contributed to the advancement of che-miſtry, it is but reaſonable to take notice of ſome of the moſt diſtinguiſhed among thoſe ſingular geniuſes.

In the thirteenth century, Albert the Great, a Domi-nican of Cologn, and afterwards of Ratiſbon, was repu-

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ted a magician ; and compofed a work, which contain
defcriptions of many alchemical proceffes.

Roger Bacon, born in the year 1214, near Ilçheſte
in the county of Somerfet, ſtudied at Oxford, and cam
afterwards to Paris to profecute his ſtudies in mathema
tics and medicine. He is celebrated as the author o
feveral inventions ; any one of which might well intitl
him to immortality, Among theſe are the camera ob
fcura, the telefcope, and gunpowder. He is faid to hav
made a felf-moving chariot, a flying machine, a fpeakin
head, &c. He was a cordelier, and was firnamed th
Admirable Doctor. Being accufed of magic, his fellow
were obliged to imprifon him. He afterwards refidei
in an houfe in Oxford, where he is faid to have workei
in alchemy Borrichius faw the houfe, which was ſti.
known by his name *.

Arnold of Villeneuve, born in Languedoc in 124!
died in 1310, having ſtudied medicine at Paris for 3
years. He wrote a commentary on the Schola Salerm
tana. The alchemiſts refpect him as one of their grea
eſt maſters. Borrichius, in the year 1664, faw one ◄
his defcendants, an alchemiſt, in Languedoc.

Fourteenth century. Raymond Lully, born in Majo:
ca in 1235, came to Paris in 1281; where he becanc
acquainted with Arnold of Villeneuve, and ſtudied ur
der him. Robert Conſtantine relates that he had fee
in the Tower of London, a Rofe Noble ſtruck out ◄
gold, made by Lully, under the reign of Edward V. i
           tʰ

* Concerning this houfe, if I miſtake not, a tradition has been loᵍ
known at Oxford ; that when a greater man than Roger Bacon paſſ
beneath it, it will tumble down upon his head. It ſtands on a bridg

    "*And* Bacon's manſion trembles o'er his head." Johnson.—ᴵ

the years 1312 and 1313. He has left feveral books on alchemy, which contain fome facts relative to the prepa- ration of acids, or aquafortis, and the properties of metals.

Fifteenth century. Bafilius Valentinus, a Benedic- tine of Erfort in Germany, was fkilled in medicine and natural hiftory. He has left a work on antimony, un- der the pompous title of *Currus triumphalis Antimonii,* on which a commentary has been written by Kerkrin- gius. This book defcribes a confiderable number of antimonial preparations, which have been fince offered to the world as new difcoveries, under different names, and have been prefcribed with great fuccefs for the cure of feveral diforders.

The two Ifaacs of Holland, father and fon, though but little known, have left fome treatifes which are praifed by Boerhaave, and from which they appear to have been acquainted with aqua fortis and aqua regia.

All thefe authors have written on chemiftry in a ve- ry obfcure confufed manner. Though acquainted with fome proceffes of folution, extraction, and purification, &c. their pretenfions rofe much higher than their know- ledge; and fcarce any advantage can be derived from a perufal of their works.

IV.

The univerfal Medicine ; Pharmaceutic Chemiftry ; Al- chemy oppofed, from the fixteenth to the middle of the feventeenth Century.

THOUGH the vain projects of the alchemifts had been invariably unfuccefsful, and had been almoft always at- tended with the lofs of fortune and reputation ; yet, in

the

the fixteenth century, a prodigious number appeared
at the head of whom was Paracelfus, a Swifs phyfician
born at Zurich in 1493, whofe reveries were eagerly em
braced by the reft. This fanciful man afferted, tha
there was an univerfal medicine, and fubftituted chemi
cal preparations in the place of the Galenical pharmacy
then in ufe. He cured many difeafes in which the or
dinary remedies had been ineffectually applied, and par-
ticularly venereal complaints with mercurial prepara-
tions. He performed fome very furprifing cures; bu'
became fo extravagantly flufhed with his fuccefs, as to
burn in public the writings of the Greek phyficians. He
died amid his imaginary triumphs in an inn in Saltz
burgh, at the age of 48, after having promifed himfeli
immortality from the ufe of his fecrets.

Notwithftanding the extravagance and abfurdity of
his idea of an univerfal medicine, it attracted the atten-
tion of alchemifts, and revived the fpirit of alchemy,
Several imagining that they had difcovered the univer-
fal medicine, affumed the new title of *Adepts.* Among
thefe were, at the beginning of the feventeenth century,

1. The Roficrucians, a fraternity that arofe in Ger-
many, were never known but by name in France, and
whofe individual members never made any public ac-
knowledgement of their principles : They pretended
to be in poffeffion of the art of tranfmutation, the uni-
verfal fcience, the univerfal medicine, and the fcience
of occult things, &c :

2. A wandering fellow, named Alexander Sethon
or Sidon, who is faid to have performed the work of
tranfmutation in Holland, in the prefence of a perfon
of the name of Hauffen : Hauffen related the fact to
                                                Vandel

Vander Linden, grandfather to the phyfician of that name, who collected a medical library :

3. Another named Thomas Vaughan, born in England in 1612. He went to America, where Starkey faw and received gold from him. Boyle correfponded with him. This is the fame adept who, in France, gave his powder of projection to Helvetius. The latter, in confequence of this pretended miracle, which was nothing but a trick, wrote a differtation *De Vitulo aureo*, &c.

Yet the fuccefs with which Paracelfus had prefcribed his chemical medicines, induced a number of phyficians to cultivate that new art; and in a fhort time feveral valuable works appeared on the preparation of chemical medicines. Such are the works of Crollius, Schroder, Zwelfer, Glafer, Tackenius, Lemery, &c.; as well as the pharmacopœiæ publifhed by the principal faculties of medicine in Europe. About this time Glauber, a German chemift, rendered an important fervice to his art, by examining the refidues of operations, which had hitherto been always thrown afide as ufelefs, and diftinguifhed by the name of *caput mortuum*, or *terra damnata.* He difcovered by this means the neutral falt which bears his name, and the ammoniacal vitriolic falt, and explained the chemical proceffes neceffary in preparing mineral acids, &c.

Several of thofe who have contributed to the advancement of chemiftry fince the days of Paracelfus, were not fully convinced of the abfurdity of his wild notions. Among thefe were Caffius, known for his precipitate of gold ; Sir Kenelm Digby, who believed in the fympathetic action of medicines ; Libavius, who has communicated his name to a preparation of tin ;

Van Helmont famous for his fingular notions both in chemiftry and medicine; and, laftly, Borrichius, a Danifh phyfician and chemift, who firft difcovered and made known to the world the poffibility and the manner of inflaming oils with the nitrous acid, and who deferves the gratitude and refpect of the world for having bequeathed his library and chemical laboratory to the ufe of indigent ftudents of medicine.

Alchemy was now oppofed by two celebrated geniufes, who were fuccefsful in their attacks. The one, the celebrated Father Kircher the Jefuit, to whom we are indebted for a noble work, intitled *Mundus Subterraneus;* the other, the learned Conringius.

V.

Rife and Progrefs of philofophical Chemiftry, from the middle of the feventeenth to the middle of the eighteenth Century.

Hitherto chemiftry had never been treated in a philofophical manner. The chemical arts had indeed been defcribed, medical formulæ had been given, and the nature of metals painfully examined, in the hopes of making gold, or difcovering an univerfal medicine: A chimera ftill fondly believed by the ignorant and enthufiaftic! But nothing more had been done. A great number of chemical facts were known; but none had attempted to form them into a fyftem: And, as the celebrated Macquer has ingeniouly obferved, though many branches of chemiftry were known and practifed, the fcience itfelf was not yet in exiftence.

Towards the middle of the feventeenth century,

James

James Barner, phyfician to the King of Poland, arrang-
ed the principal facts then known, in a methodical man-
ner, accompanying them with obfervations, in his *Phi-
lofophy of Chemiftry.* The work of that learned author
is the more valuable, on account of his being the firft
who attempted to form a complete fyftem of chemical
knowledge, and ranked chemiftry among the fciences.

Bohnius, profeffor at Leipfic, wrote alfo a book on
fcientific chemiftry, which was very favourably receiv-
ed by the world, and was long the only elementary
book on the fubject.

Joachim Beccher of Spires, a man of very confide-
rable genius, phyfician to the Electors of Mentz and
Bavaria, diftinguifhed himfelf fo highly in this fcience
as to caufe the names of the two laft mentioned writers
to be almoft entirely forgotten. In his noble work,
intitled *Phyfica fubterranea,* he has collected all the
chemical phenomena at that time known, and has de-
fcribed them with amazing accuracy. He has even
foretold many of the difcoveries which have been fuc-
ceffively made fince he wrote; fuch as the exiftence
of aeriform or gazeous fubftances; the poffibility of
reducing animal bones into a tranfparent glafs, &c.
A celebrated phyfician, whofe name marks the com-
mencement of a new and more illuftrious æra in the
annals of chemiftry, has done him the honour of writ-
ing a commentary on his work. J. Erneft Stahl, who
was born with a natural fondnefs for chemiftry, under-
took to illuftrate the doctrine of Beccher by a commen-
tary. His favourite object, to which he more parti-
cularly directed his attention, was to demonftrate the
exiftence of that inflammable earth which he denomi-

nated

nated Phlogifton. Not inferior to Beccher in genius,
he excelled him in accuracy and method. His treatifes
on fulphur and falts, together with that which is intitled
Trecenta Experimenta, have acquired him immortal
honour, and have ranked him among the firft charac-
ters of the age in which he appeared.

. Boerhaave, amid his various engagements, found lei-
fure to cultivate chemiftry, and compofed a very pro-
found work on this fcience, which has long been highly
celebrated. The treatifes on the four elements, parti-
cularly that on fire, which form a part of this work, are
each of them mafterpieces, containing all that was at
that time known on their particular fubjects. He was
alfo the firft who attempted to analyfe vegetables; and
to him we owe the fpiritus rector, &c.

Stahl's theory has been generally adopted by fuc-
ceeding chemifts, and has acquired greater ftability
from the labours of the two illuftrious brothers Meffrs
Rouelle, to whom we are chiefly indebted for the pro-
grefs which chemiftry has made in France, and whofe
lofs is feverely felt by the chemical world.

The illuftrious Macquer, of whom death has now
deprived the philofophical world, contributed in a very
fignal manner to the advancement of the fcience; and
his valuable works are ftill juftly efteemed, over all
Europe, as the beft guides to chemical knowledge.
Befide the important fervices which he performed to
the world, by publifhing his Dictionary and Elements
of Chemiftry, his inquiries and difcoveries concerning
the nature of arfenic, Pruffian blue, the dyeing of filks,
clays for pottery, &c. might well immortalize his name,
and intitle him to the gratitude of pofterity.

                                                    IV.

VI.

Pneumatic Chemistry: the present Time.

STAHL, being wholly engaged in demonstrating the existence of phlogiston, and tracing it through all its combinations with other bodies, seems to have overlooked the influence of air in most of those phenomena in which he ascribes so much to the energy of the inflammable principle. Boyle and Hales had already shown the necessity of referring many chemical phenomena to the operation of that fluid. Boyle had taken notice of the difference of the appearances which the same chemical events exhibit in the open air and *in vacuo*. Hales had obtained from a variety of bodies a fluid which he took for air, but in which he observed a number of peculiar properties; such as smell, inflammability, &c. according to the nature of the substances from which it was obtained. He was led to consider air as the principle on which the consistency and solidity of bodies depended.

Dr Priestley, by repeating a great part of Hales's experiments, discovered a number of fluids, which, though they have the appearance of air, yet differ from it in all their essential properties: and, in particular, from metallic calces he extracted a species much purer than atmospheric air.

M. Bayen, a chemist deservedly celebrated for the accuracy of his researches, examined the calces of mercury, and found that they are reducible without phlogiston, and that during the process they emit an aëriform fluid in great abundance.

M. Lavoiſier, ſoon after this, diſcovered, and proved by a number of fine experiments, that in the proceſs of burning or calcination, a portion of the air always enters into combination with the body which is calcined or burnt. In conſequence of this diſcovery, he formed a ſect of chemiſts who agreed with him in doubting the exiſtence of *phlogiſton,* and aſcribed to the fixation or the diſengagement of air all thoſe phenomena which Stahl had referred to the ſeparation or the combination of *phlogiſton.* It muſt be granted, that this doctrine has been more fully demonſtrated than Stahl's ; and that it agrees better with that accuracy and method which have of late been introduced into the ſtudy of natural philoſophy. In this light did it appear to the late M. Bucquet, who in his two or three laſt courſes of lectures ſeemed to give it the preference. The moſt prudent part on this occaſion certainly was, to wait till it could be determined by a greater number of facts, whether all the phenomena of chemiſtry might be explained by the theory of gaſes, without our having recourſe to *phlogiſton.* M. Macquer, ſenſible that a conſiderable revolution muſt neceſſary take place in the ſyſtem of chemiſtry in conſequence of theſe diſcoveries, but thinking it impoſſible to account for all the phenomena without admitting the preſence of an inflammable principle, ſubſtituted light in the room of *phlogiſton ;* as the exiſtence of the latter had never been ſtrictly demonſtrated, while the influence of light on many chemical phenomena is a well known and undeniable fact.

Since the death of that celebrated chemiſt, the ſcience has been enriched with a variety of diſcoveries, all

tending to confirm the new theory. The multitude
of faƈts which I have been colleƈting during a period
of twelve years, and the number of the experiments of
other chemiſts, which, on a repetition of them, I have
found to be attended with the fame refults, have finally
convinced me of the juſtnefs of that theory, and have
led me to confider thofe naturaliſts who ſtill continue to
maintain, with more or lefs keennefs, the exiſtence of
phlogiſton, as either unſkilled in the fcience, or inca-
pable of accuracy in their experiments.

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C H A P.

C H A P. III.

Concerning the Chemical Attractions or Affinities.

IN the firſt chapter it was obſerved, that the means
uſed in performing chemical operations, which have
been arranged under the two general heads of Analyſis
and Synthesis, are imitated from Nature, who employs
them in her operations. To illuſtrate that truth, we
ſhall here explain what is underſtood by the chemical
affinities.

A perſon cannot even enter upon the ſtudy of na-
tūre, without taking notice of that wonderful mutual
force by which all natural bodies are attracted towards
each other. On this great and univerſal law, all thoſe
phenomena depend which the philoſopher contemplates
with curioſity, and which even the moſt ignorant of
men cannot behold without admiration.

This force, by which indeed the order of the uni-
verſe is maintained, actuates the moſt minute bodies as
well as the moſt enormous maſſes of matter. But it
acts by laws, either eſſentially different, or at leaſt
differently modified, according to the maſs, conſiſtency,
and diſtances, of the bodies ſubject to its influence.
Without examining its effects on the planetary bodies,
whoſe diſtances and motions it regulates; let us con-
ſider in what manner it affects the different parts of
the globe which we inhabit, that we may by this
means diſcover its laws.

Natural philofophy teaches, that when two folid bodies of the fame kind come into contact, they adhere together with a degree of force proportioned to the extent of fmoothnefs of the furfaces in contact. Thus, two planes of glafs, or two fections of a ball of metal, if preffed together, unite with a degree of tenacity which renders a confiderable effort neceffary to feparate them. This force produces all the phenomena obferved in chemiftry. It becomes, therefore, an object of the higheft importance to ftudy all its laws, and inquire what variations it undergoes from diverfity of circumftances.

The greater part of chemifts have denominated this force *affinity* or *relation ;* becaufe it has been thought to depend on an analogy or conformity of principles in the bodies between which it fubfifts. Bergman has given it the name of *chemical attraction :* and though its phenomena are different from thofe of the planetary attraction firft obferved by Newton, yet, as both depend upon the fame principle, we fhall follow Bergman in the ufe of the name. Chemical attraction may take place between bodies of the fame nature ; or between bodies of different natures. Let us confider it under thefe two points of view.

§ I. *Concerning the Attraction or Affinity that takes place between Bodies of the fame Kind, or the affinity of Aggregation.*

WHEN two bodies of the fame nature, for inftance two globules of mercury, placed at a certain diftance from each other, tend, by virtue of this force,

to unite, and do actually enter into union, they'l
fphere greater in bulk, but precifely the fame in 1
In that event, therefore, this force affects only the
fical, or obvioufly apparent qualities of bodies ; i
feparate portions of fimilar matter ; by confound
gether feveral diftinct maffes, it forms a body of {
bulk, and unites a number of feparate parts in
whole. It is denominated the *attraction or affi
aggregation*, in order to diftinguifh it from that
takes place between bodies of different natures.
duces an aggregate in which the phyfical qual
the bodies united undergo a new modification,
out any fenfible change being produced in their
cal qualities. The *aggregate* is nothing more tha
herent body, the parts of which are retained in
by the force of aggregation. It muft be diftin{
from the mafs called an *heap ;* for though an he:
fift of parts all of a fimilar nature, yet thofe p:
difpofed loofely, and without coherence. It is l
to be diftinguifhed from a *mixture ;* which conf
quantity of diffimilar particles blended togethe
out adherence. This may be farther explaine
familiar example : Flowers of fulphur, or ful{
powder, whofe parts have no adhefion, and ma
parated by the flighteft effort, compofe an he
parts of which are not affected by the affinity o:
gation. This mixed with another heap, with
inftance confifting of nitre in powder, gives wha
led *a mixture by confufion.* But if, by the hel{
fion and cooling, you fubject this heap to the p
aggregation, the molecules or integrant parts
fulphur will then be drawn towards each other

its liquefaction, and will mix and unite in such a man-
ner as to form, when cooled, an uniform mafs or folid,
which will be a true aggregate.

The force or affinity of aggregation exifts in various
degrees, which are meafurable by the effort neceffary to
feparate the integrant parts of any aggregate body.
We fhall diftinguifh aggregates into four kinds, under
which all the bodies in nature may be arranged.

1. The firft is the *hard or folid aggregate*, in which
the integrant parts are united by a very confiderable
force, and cannot be feparated without great exertion.
This genus comprehends many fpecies or degrees, from
the hardnefs of the precious ftones and of rock-cryftal,
to the yielding contexture of the fofteft wood. Its pe-
culiar charaĉteriftic is to form a mafs, the conftituent
parts of which cannot fuffer any difcernible motion
without being divided.

2. Bodies whofe conftituent parts may be eafily
moved backwards and forwards, fo as to change their
relative fituation, without being feparated, belong to
the foft aggregate. Lefs force is requifite to maintain
the cohefion of a foft body than to preferve the con-
fiftency of a folid aggregate; and lefs reaĉtion to de-
ftroy it.

3. *The fluid aggregate.* Its integrant parts are fo
flightly united, that the gentleft effort is fufficient not
only to change their relative fituation, but even to di-
divide them into diftinĉt globules.

4. Laftly, the *aëriform aggregate*, the tenuity of
whofe integrant particles renders them imperceptible,
and in which the affinity of aggregation is the leaft

poffible.

poffible. The air of the atmofphere affords an example of this.

Thefe four kinds of aggregate are, properly fpeaking, but different degrees of the fame force : but it is abfolutely neceffary to diftinguifh them accurately from one another; becaufe they have an important influence on the operations and phenomena of chemiftry, which is diverfified according to their differences : yet it may be proved in the moft fatisfactory manner, that they are only fo many different degrees of the fame force ; for many bodies are capable of affuming each of thefe four ftates fucceffively. Water, in the form of ice, is a folid aggregate ; its hardnefs is greater in proportion as its temperature is lower; when expofed to the temperature of 32° Fahrenheit, it affumes a kind of foftnefs * before paffing into a fluid ftate. Its exiftence in this laft ftate is univerfally known : and philofophers have calculated what degree of expanfive force is neceffary to reduce it to vapour ; in which ftate it becomes an aëriform aggregate. Metals, greafe, concrete oils, wax, &c. may be in the fame manner made to pafs through thefe feveral ftates of aggregation.

The more particularly any perfon is acquainted with the laws of chemical attraction, fo much the more will he be convinced of the importance of diftinguifhing between thefe feveral kinds of aggregation, and eftimating each of them aright. Accurate ideas concerning each of them are effentially neceffary to enable us to compare this with the fecond fpecies of chemical attraction, which will come next to be examined.

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* A doubt expreffed by the tranflator of the fecond edition, induced me to repeat this experiment ; and I found that M. Fourcroy had by no means mifreprefented the fact.—H.

As thefe two kinds of affinity, though they appear to depend on the fame caufe or principle, yet in all the phenomena of chemiftry feem to act in direct oppofi-tion to each other (for it may even be inferred from facts which fhall be related, that they are in the inverfe ratio of each other), it is abfolutely neceffary for the chemift to weaken or deftroy the one, when he wifhes to effect any operation by means of the other. Now, the attractive force of which we have been fpeaking, is al-moft always that which he has occafion to diminifh; and it likewife admits of various modifications by the power of art.

All that is neceffary to deftroy or weaken the affini-ty of aggregation, is, to oppofe to the cohefion of the aggregate an external force more than fufficient to counterbalance that which preferves the union of its component parts; and the external force applied muft therefore be proportioned to the cohefion of the parts. This is the great law to be always obferved in the pre-paratory operations; the fole purpofe of which is to def-troy the affinity of aggregation. Pulverization, grind-ing, rafping, filing, and cutting, are fo many means for counteracting the cohefion of bodies and dividing their conftituent parts. Heat and evaporation produce the fame effects on fluids, and on thofe folids which are fufceptible of dilatation or fufion. But thefe laft mentioned operations being effected by heat, come pro-perly under the fecond fpecies of chemical attraction; as does alfo the folution of bodies by water.

As art can apply a great variety of means to coun-teract, and even deftroy the force of aggregation; fo it likewife affords others to reftore it, and caufe it to

act with all its former energy. All the manipulations which it employs for this purpose, consist in placing the bodies, whose force of aggregation is to be restored, in such a state of division and fluidity, that their particles may be at liberty to obey the power of attraction, by applying to each other those of their surfaces which are best adapted to unite; and they thus form a new aggregate, which, in regularity of figure and cohesive force, is generally equal, and sometimes superior, to natural aggregates of the same kind. We may take this opportunity to observe, that all aggregate bodies may be divided by their figure into two classes, Regular and Irregular. Every body in nature appears under the one or the other of these two forms; and art, which always emulates, and sometimes even rivals, nature, can produce at pleasure a regular or an irregular aggregate. All substances capable of passing through the several states of aggregation above enumerated, but more especially salts and metals, may be so managed during the process by which they are reduced from a fluid to a solid state, as to assume the form either of an irregular mass, or of a body with regular lines, angles and surfaces, which is called a crystal. The first form is obtained by keeping the particles of the fluid body, whether its fluidity may have been occasioned by fire, or water, very near to each other; and causing the liquefaction to cease suddenly, so that they may come into contact all at once, and the affinity of aggregation may cause them to unite into one solid mass. But, on the contrary, to produce crystallisation, it is necessary to keep the parts of the body which you wish to bring into that state, at as great a distance as possible from

one

one another, that they may remain for fome time in a
kind of equilibrium, before coming into union, and
may prefent to each other fuch of their furfaces as are
beft adapted to unite. From this it appears, that cry-
ftallifation is entirely owing to the affinity of aggrega-
tion ; and if the phenomena of cryftallifation be obfer-
ved with a proper degree of attention, they will afford
an idea of the manner in which the affinity of aggrega-
tion acts. For this purpofe it is mentioned here : it will
be more particularly explained under feveral future ar-
ticles of this work.

§ II. *Concerning that Species of Chemical Attraction*
which unites particles of different Natures ; or the
Affinity of Compofition.

WHEN two bodies differing in nature have a ten-
dency to unite, they enter into combination by virtue
of a power fomewhat different from that which we
have been confidering : it has been denominated *the*
affinity of compofition; but may be with more propriety
named *the attraction of compofition.* This fpecies of
attraction or affinity is of ftill greater importance than
the former, as it acts in all chemical operations, and
none of thefe can be explained without it. The ex-
iftence of this power has been always known; but it
was not obferved with the attention which it juftly
merits, till fuch time as it appeared to affect the prac-
tice no lefs than the theory of the fcience of which we
are treating. A knowledge of this affinity is effenti-
ally neceffary to direct the practitioner who purfues a
train of experiments, as well as the philofopher who

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collects and compares facts. This is the compass by
which both must steer; and it may be affirmed, that
whoever is well acquainted with the laws of chemical
attraction, is acquainted with the extent and sublimi-
ty of the science.

Convinced of this truth, we shall here make it our
bufinefs, firft, to exhibit faithfully all the facts which
can ferve to illuftrate the nature of this affinity; and,
next, to give an account of thofe hypothefes which
have been formed to explain its caufe.

Obfervation, the parent not only of chemiftry but
of all experimental fcience, has fhown, that the attrac-
tion, or affinity of compofition, prefents certain inva-
riable phenomena; which may be confidered as laws
eftablifhed by nature, and which can efcape the obfer-
vation of none but fuch as are incapable of examining
them with due attention. Thefe laws, founded on a
vaft variety of well-eftablifhed facts, may be reduced
to eight; which are as follows,

I. *Firft Law of the Attraction of Compofition.*

*The attraction, or affinity of compofition, cannot act but
between bodies of different natures.*

This firft law is invariable, and admits of no excep-
tions. That two bodies may combine, and form a
compound, it is indifpenfibly neceffary for them to be
different in kind. Join two bodies of the fame nature,
and you form only an aggregate, of which the bulk and
extent are enlarged, but its effential properties remain
unaltered; and their union is occafioned and preferved

by

by the affinity of aggregation, conformably to the explanation already given of the nature of that affinity. Thus, two pieces of wax, refin, or fulphur, may be united by the action of heat ; and this inftance is fufficient to explain the difference between aggregation and compofition.

This law holds fo invariably, that the attraction of compofition is never ftronger than when the bodies between which it acts are, in nature, the moft effentially different from one another. Thus acid falts and alkali, though the properties of the one are directly oppofite to thofe of the other, enter into the moft intimate mutual combination, and form the moft perfect compound. The fame oppofition fubfifts between the properties of alkalis and fulphur, of acid falts and oil, of acids and metals, of water and fpirit of wine, &c.; all which fubftances have a ftrong tendency to mutual union.

It is the more neceffary for us to gain an accurate knowledge of this great law of the affinity of compofition, becaufe a number of chemifts, with Stahl at their head, have laboured to prove, that bodies never enter into combination, but in confequence of a certain relation, or refemblance between their properties: an opinion to which no perfon will agree who knows the full extent of this primary law. When reading the reafonings even of the moft eminent chemifts on this fubject, we cannot avoid obferving, that the relations which they labour to point out between thofe fubftances which have the ftrongeft tendency to mutual union, appear always extremely remote ; and that, by the fame means, refemblances might be eafily found out between bodies the moft diffimilar. It is eafy to fee, however, that th

inge

ingenious men have propofed this theory, merely from
defire to fimplify and illuftrate the doctrine of chemica
attractions: and thofe who are fenfible of the difficult
of eftablifhing fyftems in any of the departments of hu
man knowledge, will always confider them as entitle
to the gratitude of every friend of fcience. Their labou
have not been without their ufe, as they have collect
a number of facts, and pointed out their connectio
But a regard to truth, which it becomes, us to prefer.t
every other confideration, obliges us to confefs our ign
rance of the caufe of this important phenomenon, it
ftead of referring it to an analogy, the exiftence
which is inconfiftent with thofe ideas of the propertie
of bodies which we derive from experiment.

II. *Second Law of the Attraction of Compofition.*

*The attraction of compofition acts only between the m
nuteft particles of bodies.*

In order to form a juft idea of the nature of this la
it is neceffary for us to diftinguifh chemical from ph
fical fubjects. Thefe laft are bodies whofe extern
qualities, fuch as weight, bulk, furface, extent, and 1
gure, are perceptible to our fenfes, and may be eftim:
ted by their effects upon them. Aggregates are the b
dies whofe qualities are obferved and compared by th
naturalift. Chemical fubjects, again, are fubftanc
which have loft their aggregation; and which, of co
fequence, no longer prefent to the fenfes the phyfic
properties of aggregates. They are minute particl
the extent of which cannot be meafured, nor their bu
or form diftinguifhed. It is not till after bodies ha

been reduced to this state of tenuity by the several pre-
paratory operations above-mentioned, that they become
subject to the affinity of of composition; and the chemist
cannot cause them to enter into combination, without
presenting them to one another in a state of division.
This force seems to actuate none but the minutest par-
ticles of bodies: and in this manner does the attraction
of composition appear to differ from that which acts be-
tween large masses of matter. The difference is still
more striking when we consider the constant opposition
between the attraction of aggregation and that of com-
position. This opposition is so invariable, that we may
even venture to advance it as a chemical axiom, that the
attraction of combination is in the inverse ratio of that
of aggregation; these two forces being always in oppo-
sition, and forming a kind of counterpoise to each other.
The attraction of aggregation always resists the combi-
nation of different bodies; where it acts with the great-
est force, they have scarce any tendency to mutual u-
nion; and again such substances as are the least under
the influence of the force of aggregation, have a strong
tendency to combine with others. The various kinds
of *gas*, or air, for instance, of all known substances are the
least under the influence of the force of aggregation; and
of them there are many whose tendency to combination
is so strong, that they combine with the greatest facility
with almost any natural body. Yet we shall afterwards
see that this happens only when the heat which enters
into the composition of elastic fluids is but slightly combi-
ned with a base; and that the aëriform state often occa-
sions a contrary tendency; as for instance, in pure air.

III. *Third Law of the Attraction of Composition.*

The attraction of composition can unite more bodies th.
two.

THIS law of chemical attraction is one of those whi
have been eftablifhed by the feweft obfervations; a
we are ftill but very imperfectly aquainted with its e
tent.   We are acquainted with a vaft variety of tho
combinations which are produced by the union of tv
bodies; with a few which are formed by the union
three ·bodies; but we know of fcarce any inftances :
which four different bodies have an equal tendency
enter into mutual combination, and remain in this ftat
Metals are the only bodies that are known to be cap
ble of this laft fpecies of combination; and of whic
two, three, or four, may be effectually blended tog
ther.   It is highly probable that there are in natu
combinations made up of more than four bodies, of f
or eight, for inftance; but with fuch we are hithert
unacquainted.   The reafon why fo little progrefs h
been made in the ftudy of this law, fhall be explaine
when we come to treat of the eighth law of the affinit
of compofition.   The number of the fubftances of whic
any compofition confifts is denoted by faying, the aff
nity of one, two, three, or four bodies, and fo on.   Th
rapid progrefs which chemiftry has of late begun t
make, the multiplicity of its refearches, the variety
the objects to which thefe are directed, and the fcru
pulous accuracy of obfervation with which they are con
ducted, afford us reafon to hope that thofe affinitie
which are named *complex* will foon be better known.

IV

IV. *Fourth Law of the Affinity of Compofition.*

That the affinity of compofition may take place between two bodies, at leaft one of the two muft be in a fluid ftate.

THIS law has been long known to chemifts, and has been long expreffed in this axiom, *Corpora non agunt, nifi fint foluta.* Uniform and accurate obfervation has fhown that two folid fubftances can never enter into mutual combination. Even bodies which have the ftrongeft tendency to unite, cannot be brought into union till either the one or the other of them be reduced to a fluid aggregate. Bodies enter into combination with more or lefs facility, according as they are more or lefs in a ftate of fluidity, and confequently poffefs more or lefs aggregative force: and therefore no two bodies enter into combination with fuch rapidity as any two of the faline aëriform fluids; for inftance the muriatic acid gas and the alkaline gas.

Though no two folid bodies can enter into combination with each other; yet in fome inftances dry fubftances, reduced into a fine powder, re-act upon each other with fo much energy, as to unite and form a new compound. Thus I have difcovered that cauftic fixed alkali, when reduced by trituration, unites in a cold dry ftate with fulphur, antimony, and kermes, as I fhall elfewhere more particularly relate: but in this inftance, the reduction of the bodies into their moft minute particles by pulverization, and the moifture of the atmofphere attracted by the falt, which foon deliquates, have a confiderable fhare in effecting the combination;

nomenon takes place, to which chemifts have g
name of *folution.* It confifts in the attenuation,
and entire deftruction of the folid body in cont
the fluid. The caufe of this phenomenon is,
attraction of combination between two fubftar
of which is a liquid, the other a folid, fuch as
phureous acid, and a bit of calcareous fpar, is
than the aggregative force which preferves the
of the folid in exclufive union with one anothe
fince, by the third law, this fpecies of attractio
act but on the moft minute particles of bodies,
muft neceffarily lofe its aggregation, and be rec
to very fmall particles, in order that it may
with the *fulphuric* acid, and form *calcareous*
Formerly, chemifts always diftinguifhed betwee
dy which effected and that which fuffered the ac
tion : the former was the fluid, the latter the fc
modern chemifts refufe to admit this diftinctic
fuppofes a force in the fluid fuperior to what exi
folid aggregate. M. Gellert was the firft who
that the two bodies contribute equally to the t
lution ; and that in the above inftance, the vitr
could not deftroy the aggregation of the fpar,
the fpar a tendency to unite with the fulphuric
lefs ftrong than that of the acid to combine witl
name *folvent,* therefore, given at prefent to flui
ftrictly chemical, as it conveys only the idea

chanical operation ; and it were better to lay it afide.
But fince it has been unluckily introduced, the ftudent
of chemiftry muft always remember, that when one bo-
dy is faid to diffolve another, no more is meant than that
the former is in a fluid ftate, and that the fluid can never
poffefs greater activity or energy than the folid ; but the
folid may rather be confidered as poffeffing thefe qualities
in a fuperior degree, fince its tendency to combination
is fo powerful as to overcome its aggregative force.

The falfe idea of folution which has prevailed till
of late, arofe no doubt from the mechanical theory by
which fome philofophical chemifts have fought to ex-
plain this operation of nature. This theory, which ap-
pears in every page of Lemery's chemiftry, confifts in
confidering the folvent, an acid, for inftance, as an af-
femblage of very acute points, and the body to be dif-
folved, as containing a vaft number of pores, into which
the points of the acid infert themfelves, fo as to disjoin
the particles of the body, and reduce them to that ftate
of divifion in which the aggregate difappears. To men-
tion this opinion is, at prefent, all that is neceffary to
fhow its abfurdity and inconfiftency with thofe laws
which accurate obfervation has eftablifhed in the expe-
rimental fciences.

V. *Fifth Law of the Attraction of Compofition.*

*When two or more bodies are combined by this affinity,
their temperature fuffers a change at the inftant of their
union.*

THIS phenomenon fo invariably attends all the com-
binations effected by art, that we cannot help confider-

ing

ing it as one of the laws of the attraction of compofitior
The temperature of bodies may be altered in two ways
new combinations fometimes produce cold, fometime
heat. The latter is oftener produced than the former
but as cold is certainly produced in feveral fynthetic c
perations, we have thought proper to exprefs this phe
nomenon by the general term, Change of temperature

It may be objected, that in certain folutions or com
binations which are flowly effected, no change of tem
perature is perceived : But we would defire perfons wh
are difpofed to offer fuch an objection, to immerfe
good thermometer into thofe folutions, and they wi
not fail to be convinced that a change of temperatu1
is produced. It appears from fome valuable obferv;
tions by M. Baumé, which fhall be elfewhere mo1
particularly mentioned, that this phenomenon is occ;
fioned by the change of aggregation, which the bodi'
entering into combination undergo as they pafs from
folid to a fluid ftate. But as that change is produced t
the action of the affinity of compofition, both the or
and the other evidently depend on this principle.

Macquer has given it as his opinion, that the vari
tions of the temperature of bodies entering into con
bination, are occafioned by the motion of their com
ponent particles : but though we fhould admit this a
an happy account of the caufe of the heat produce
in new combinations, ftill the cold which takes plac
in fome of them remains unexplained. Several mo
dern chemifts, particularly Scheele and Bergman, con-
fider heat as a diftinct body, acting a principal part in
all chemical combinations ; and affert, that change of
temperature arifes from the abforption or difengage-

3   ment

ment of this body. This theory affords a good ex-
planation of the caufe of that change of temperature
which takes place when a new combination is pro-
duced.

VI. *Sixth Law of the Attraction of Compofition.*

*Two or more bodies united by the attraction of compo-
fition. form a fubftance, the properties of which are diffe-
rent from thofe which each of the bodies poffeffed before
their union.*

It is of importance to eftablifh the exiftence of this
law; becaufe many celebrated chemifts of the prefent
age, have entertained opinions concerning the proper-
ties of compounds, which to us appear inconfiftent with
a great number of facts, and are directly contradictory
to what we here offer as one of the principal phenome-
na of the affinity of compofition.

Stahl and his followers, whofe genius has, in other
inftances, rendered fo many important fervices to che-
miftry, have afferted, that compounds always partake
of the properties of thofe bodies of which they are
compounded, and poffefs a kind of middle nature be-
tween their principles. They have even carried this
notion fo far as to perfuade themfelves, that it is poffi-
ble to determine the peculiar properties of any princi-
ples, by examining the compound formed by their
union. Thus, Stahl pronounced falts to be a com-
pound of earth and water, becaufe he thought he could
diftinguifh their properties to be intermediate between
the properties of thefe two fubftances. As we are to

examine

principle; and to fome of them when combined
acids, &c. *.

The confiftency of bodies is alfo affected by
combination; the confiftency of a compound beii
moft always different from that of either of the f
bodies of which it is compofed. Thus, two flui
ten produce a folid by their combination; for infl
the fulphuric acid united with a folution of p
And again, a fluid often refults from the combir
of two folids; as from a combination of neutra.
with ice, and from the mixture of an amalgam o
with an amalgam of bifmuth. But the quality ᾿
fuffers the moft frequent alterations in the combir
of bodies is colour. Sometimes it is loft : thus th
loured muriatic acid, combined with a metal, ber
white. But it oftener happens, that two bodies
tute of colour, affume when united either a fain
ftronger colour, as when iron or copper are diffol·
almoft any of the acids, and when the calces ol
mercury, or almoft any other metal, are united
oxygen.

· Many bodies, which in a fimple ftate, are ftror
doriferous, become inodorous when brought into
bination; as for inftance, muriatic acid gas an
moniac or alkaline gas, which in a fimple ftate h
ftrong fuffocating fmell, form in combination amn

* We cannot avoid making ufe of terms and denominations
explained. But the reader may have recourfe to the table fubj
the end of the laft volume, and to the beginning of our acc
the feveral articles to which fuch names belong, for an explan
them. This inconvenience, though it may perplex the begint
not be otherwife obviated.

eal muriate, a neutral falt that has fcarce any fmell.
Again, from the union of two indorous bodies, there
often refults a ftrong-fmelling compound ; fulphur and
fixed alkali, each of which is in a fimple ftate almoft def-
titute of fmell, form, when united, liver of fulphur, or
fulphure, a fubftance which in a moift ftate is extremely
fetid.

The fufibility of bodies is fubject to the fame chan-
ges. Two fubftances, not fufceptible of fufion, or
which cannot be reduced to that ftate without the
greateft difficulty, when combined acquire the proper-
ty of fufibility in an high degree. Combine fulphur
with any of the metals, and you will have a ftriking
inftance of the truth of this affertion. A variety of o-
ther facts, befide thofe which have been here adduced,
concur to eftablifh this law in contradiction to the theo-
ry of StahL

VII. *Seventh Law of the Attraction of Compofition.*

The attraction of compofition is meafurable by the diffi-
culty of deftroying the combination formed between two
or more bodies.

CHEMISTS know how to feparate bodies in union,
however ftrong their natural attraction or adherence ;
but the means which they employ for this purpofe are
more or lefs eafy, more or lefs complex. It has
been uniformly obferved, that in proportion as a com-
pound is more or lefs perfect, its component parts are
feparated with more or lefs difficulty : And the degrees
of the difficulty with which any two fubftances are fe-

tion is formed, confifting of the acid and the alkal
This decompofition is commonly known by the nam
of *precipitation;* becaufe the fubftance feparated gene
rally finks to the bottom of the fluid compound.

The fubftance that finks to the bottom of the veffi
in which this operation is performed, is named a *pre
cipitate.* The fubftance by the addition of which th
phenomenon is produced, is denominated the *precip.
tant.* There are four different kinds of precipitate:
A true precipitate is formed, when the fubftance whic
finks to the bottom is one of the principles of the com
pound decompofed by the addition of the new body
When fulfate of lime, which is a combination of lim
and the fulphuric acid, is decompofed by means of po
afh, which fubftance has a greater affinity with th
acid than with lime, the lime being feparated falls t
the bottom, and conftitutes a true precipitate. A *falfe
precipitate* is produced, when the new combination of
the precipitant with one of the two fimple bodies of
the compound which it has decompofed, falls to the
bottom on account of its infolubility, while the fepa-
rate body remains in a ftate of folution. When *mercu-
rial nitrate* is decompofed by the muriatic acid, with
which the oxide of mercury has a ftronger affinity
than it has with the *nitric acid,* the new combination
of mercury with the muriatic acid finks to the bottom
of the mixture, forming a falfe precipitate, above which
the nitric acid remains diffolved in the water. This
phenomenon depends entirely, as fhall be elfewhere
fhown, on the different degrees of the folubility of the
different fubftances.

We cannot avoid obferving, in this fecond order o
precipitate

precipitates, an error of denomination which may tend
to miflead beginners. For, if this name be given to
the fubftance feparated from the compound by the pre-
cipitant, it cannot with any propriety be applied to
the new combination then formed. But though we
fhould even confine the term *precipitate* to denote the
fubftance feparated by the precipitant, it might ftill
occafion miftakes; as it happens in many cafes that the
infulated fubftance, inftead of finking, rifes and is vola-
tilized. Thus, when the combination of the muriatic
acid with volatile ammoniac or alkali, known by the
name of ammoniacal muriate, is decompofed by quick-
lime, with which the acid has a greater affinity than
with volatile alkali, the alkali evaporates, and the mix-
ture affords no appearance of any precipitate.

In order to produce thefe precipitates, it is neceffary
that the fubftances be in a liquid ftate: The procefs is
then called precipitation effected in the humid way, to
diftinguifh it from that which is accomplifhed by the
action of fire, or in the dry way, either by means of
fufion or diftillation; which operations fhall be hereaf-
ter particularly explained.

Modern chemifts have likewife taken notice of two
other fpecies of precipitate; the diftinction between
which is much more juft and ufeful than that between
the preceding. Thefe are *pure precipitates* and *impure
precipitates*. The firft comprehend all bodies which,
after their feparation from thofe compounds into which
they entered, exhibit all their original properties, with-
out appearing to have fuffered any alteration, in con-
fequence either of exifting in a compound ftate, or of
being expofed to the act of decompofition. The pre-
cipitates

cipitates of this fpecies are very numerous, but the im
pure precipitates ftill more fo.

In order that precipitates may be obtained very pure
it is requifite that they fhould have fuffered no alteratio
by the action of the bodies with which they were com
bined before their precipitation ; and that there fubfi
no affinity between them and the fubftance employed t
precipitate them.   For inftance, when *alcohol*, or fpiri
of wine, is poured into a folution of fulphate of potafl
the fpirit of wine having a ftronger affinity with th
water than the water has with the falt, the latter i
left in a feparate ftate, and becomes a pure precipitate
becaufe it has fuffered no alteration from the water
and has not the moft diftant affinity with the alkohol
But when two bodies by combination have produce
mutual alterations on each other, as happens in the
combination of acids with metals, the third body, fucl
as an alkaline falt, employed to effect a feparation be-
tween them, will give the metal in a ftate very different
from its original character, and will thus produce ar
impure precipitate.   The fame refult takes place wher
the precipitant has any tendency to unite with the
precipitate : thus, in the above-mentioned inftance o:
a metallic folution decompofed by an alkali, part ol
the alkali entering into combination with the metallic
oxide renders it an impure precipitate.   Thefe two
caufes of the impurity of precipitates are almoft always
found to act together.   We can fometimes diftinguifh
at once whether a precipitate be pure or impure, by
adding a much greater quantity of the precipitating
body than is neceffary to decompofe the compound.
This extraordinary quantity then enables the precipi-

<div align="right">tant</div>

tant to combine with the precipitate, if there be any affinity between them, and diffolves the latter fo entirely as to make it difappear. If a quantity of volatile alkali or ammoniac be poured upon a folution of copper with the nitric acid, the copper is precipitated in the form of light blue flakes. The colour of this precipitate, fo very different from the natural brilliancy of copper, fhows it at once to be an impure precipitate : If we add more ammoniac, this will ftill more plainly appear. . The blue flakes are again diffolved by the falt, the fluid becomes gradually homogeneous and tranfparent, and affumes a very fine deep blue colour ; a fure proof of the combination of the oxide of copper with the alkaline falt.

For our prefent accurate knowledge of thefe impure precipitates, which occur much more frequently than the pure, we are indebted to the refearches of M. Bayen, concerning the decompofition of mercurial folutions by alkalis, and the ftate of the mercury precipitated in this operation.

It is now eafy to underftand the theory of the decompofition of compounds of two bodies by means of a third brought into contact with them : they all depend upon fimple elective attractions.

But beginners will find more difficulty in acquiring a diftinct idea of that complicated phenomenon to which chemifts have given the name of *double elective attraction.* It often happens that a compound of two bodies cannot be deftroyed by a third or fourth body individually ; while, if a compound of the two laft be brought into contact with the firft compound, both compounds are inftantly decompofed. An example

will

will make this better underftood : Sulphate of potafh.
or a combination of the fulphuric acid with potafh.
cannot be decompofed by either quicklime or the cold
nitric acid individually ; but pour into a folution of the
former neutral falt a proper quantity of the *calcareous
nitrate*, formed by the union of the nitric acid with
quicklime, the two combinations will be mutually de-
compofed; the nitric acid uniting with the potafh
to form common nitre, while the fulphuric acid unit-
ing with the lime, forms fulphate of lime; which being
lefs liable to folution than the nitre, is therefore preci-
pitated.   This affinity may poffibly appear ftrange and
unaccountable; but it may be explained in the fol-
lowing manner : The fulphuric acid cannot be fepa-
rated from potafh, either by lime or by the nitric
acid, becaufe it has a ftronger affinity with that alka-
line fubftance than either of the two latter bodies ha
with it or with the alkali.   But when you prefent t
the fulfate of potafh a compound of the nitric aci
with lime, the nitric acid immediately exerts its tender
cy to combine with the potafh, while the fulphuric aci
is at the fame time attracted by the lime; fo that tha
decompofition of the fulfate of potafh is begun by th
action of the nitric acid, and completed by that of tha
lime. To explain this double affinity ftill more clearly,
let us fuppofe the force of adhefion, which unites the
fulphuric acid with potafh, to be equal to eight; the
nitric acid tending to unite with that alkaline fub-
ftance with a lefs degree of force, which we may efti-
mate at feven, would be infufficient of itfelf to decom-
pofe the fulfate of potafh ; but the lime by its ten-
dency to combine with the fulphuric acid, aids it with

a force which we may confider as equal to fix ; and thefe
two forces together amount to thirteen ; which fum of
forces is exerted againft the force eight, to feparate the
fulphuric acid from the potafh. This compound force
will alfo be greater than that which maintains the union
between the lime and the nitric acid.

There are therefore two kinds of attraction in double
elective attractions, which muft be carefully diftinguifh-
ed from each other : 1. The fiift is that by virtue of
which the principles of each of the two compounds ad-
here to one another, which in the above inftance retains
the fulphuric acid in union with the potafh, and caufes
the nitric acid to adhere to the lime. I fhall follow Mr
Kirwan in giving to this force the name of *quiefcent at-*
tractions ; becaufe its tendency is to preferve the two
compounds in their firft ftate. 2. The fecond is that
by which the four principles of the two compounds re-
ciprocally change their fituations, and are combined in
a different order : it is by virtue of this affinity, that in
the above inftance the potafh combines with the nitric
and the lime with the fulphuric acid. This fecond force
I fhall here denominate *divellent attractions* ; becaufe it
counteracts and deftroys the firft. From this ufeful di-
ftinction, it becomes eafy to explain the caufe of this dou-
ble decompofition, by exhibiting in a table, as Bergman
has done, the forces of the attractions by which it is
produced. Place the two compounds which mutually
decompofe one another between two braces directly op-
pofite, the acids ftanding in oppofition to the bafes on
which they act ; between thefe four bodies note down
the particular degrees of the attractive force which they
exert upon each ; add together the two horizontal num-

bers, expreffing the quiefcent attractions ; add alfo
vertical numbers which are employed to mark the
vellent attractions : if the fum of the latter exceed
of the former, a double decompofition and a double c
bination will be effected. The ufefulnefs and accu:
of fuch a table may be fhown at once by giving an
ample of it in the laft mentioned compounds.

E X A M P L E.

Nitre, or nitrate of potafh.

Sulfate of lime *.

Chemifts have but lately begun to take notic
thefe double elective attractions; and we are far f
knowing them all. Thofe who are engaged in chi
cal refearches will frequently obferve this kind of
compofition in circumftances where no fuch phenc
non was before fufpected to take place. In the hil
of faline fubftances we will repeatedly have occafio
take notice of feveral of thofe double elective attract

                                         W

* I have given ten fimilar examples of double decompofitions v
take place in the mixture of neutral falts, in two differtations ; whic
reader may confult. *See my Memoirs and Obfervati:ns on Chi*
Vol. I. 8vo, Paris, 1784, pages 308 and 438. E.

which have been lately obferved by Bergman, Scheele, &c. and by ourfelves.

Before concluding our account of this tenth and laft law of the attraction of compofition, we cannot help taking notice of an ingenious method contrived by a French chemift, to exhibit at once all the more regular phenomena of chemical decompofition. Geoffroy the elder, obferving the various relations which fubfift between different bodies, and the precipitations produced in confequence of thofe relations, with more attention than had been applied to that object by former chemift, contrived, in the year 1718, to exhibit them in a table; in which he arranged thofe bodies whofe affinities he had obferved, in the order of their affinities. We only mention that ingenious contrivance in this place; but will have many future occafions in the courfe of this work, of explaining it more particularly. Geoffroy gave that table only as a firft attempt, to which he well knew much might be added. A number of chemifts have adopted and enlarged his plan. Rouelle the elder made fome corrections on his table, and added feveral columns to it. M. de Limbourg, a phyfician at Spa, in an excellent differtation on the affinities, which, in conjunction with another by M. Sage of Geneva, gained the prize offered in 1758 by the academy at Rouen, has formed one ftill more extenfive. M. Gellert, in his Metallurgic Chemiftry, has likewife given a new table of affinities. But none has contributed more to the advancement of this part of the fcience than Bergman, profeffor of chemiftry at Upfal; whofe labours have been fo beneficial to the fcience in general. That celebrated chemift has followed M. Baumé, in diftinguifhing the

attractions

attractions which operate in the humid way, from the
which effect combinations in the dry way.   He has ;
ven two very extenfive tables, in which he exhibits t
elective attractions of a vaft number of natural bodi
To the fame philofopher we are indebted for a ve
ingenious table, in which he has found means, by a p
culiar difpofition of the chemical characters, to expr
the phenomena of double elective attraction: Of tl
we gave an example above,

    After giving this view of the leading phenomena
chemical attraction, and unfolding the laws by whic
that force appears to be regulated, we muft obfervi
that in fome cafes thefe laws feem liable to certain va
riations.   We need not here mention all the facts o
which this affertion is founded, as we fhall be careft
to take notice of them wherever they occur; only w
may obferve, that thefe feeming anomalies of chemict
attraction arife from the influence of particular circum
ftances; fuch as the quantity of the fubftances, the tem
perature of the atmofphere, motion or reft, folution b
water or fire, that is, in the humid or in the moift wa)
the ftate of aggregation proper to each body, &c. Berg
man has confidered all thefe circumftances with pecu
liar care; and has fhewn how far they may be expecte
to vary the laws of attraction. From the various fad
which he has collected relative to this fubject, he con
cludes, that their variations can be regarded only as ex
ceptions, by no means fufficient to weaken the evidenci
on which the doctrine of chemical attraction is found-
ed.

    We are led to confider two other fpecies of affinity
that have been admitted by fome authors, in the fame

        3   light,

light, the affinity of *intermediates* and the *reciprocal* affinity. By the firft, they underftand that by which bodies, which have no natural tendency to mutual union, are capable of being united after one of them has been combined with a third body, which ferves as an intermediate between them : Oil, for inftance, does not combine with water; but a combination of oil with a falt conftitutes a foap, which is foluble in water, the falt acting as an intermediate. But it is not the falt which renders the foap foluble, for its properties are entirely loft in the foap; the folubility of this compound in water is owing to the new properties it has acquired. This phenomenon falls evidently under the fixth law of chemical attraction; by which it is eftablifhed, that compounds acquire new properties totally different from thofe of their component principles.

The *reciprocal affinity* takes place when a compound confifting of two bodies is decompofed by a third, and the feparated principle again decompofes the new combination; fo that the principles feem to act reciprocally. The fulphuric acid has a greater affinity than the nitric acid with potafh, and accordingly decompofes a combination of thefe two principles; but the nitric acid, when left in a feparate ftate, has power to divide the fulphuric acid from the alkali; for by heating fulfate of potafh with the nitric acid, nitre is again obtained. This kind of affinity, admitted by M. Baumé, is occafioned by two circumftances, whofe influence difturbs the general laws of chemical affinity. The common nitric acid muft be heated before it can decompofe fulfate of potafh; and the nitre obtained by this procefs is again decompofed by the fulphuric acid, affoon

as the mixture returns to a cold ftate. The fuming, or *nitrous acid*, decompofes fulfate of potafh cold fuming fpirit of falt or muriatic acid effects the fame decompofition, according to M. Cornette : but Berg- man has very properly obferved, that the odorating and . fuming acids, which he calls *phlogifticated*, have affini- ties different from thofe which belong to them in their fimple ftate. Befides, in thefe cafes but a very trifling part of the falt is decompofed.

In all thefe inftances, the order of the elective attrac- tions is changed and modified by particular circumftan- ces. The reft of the facts on which Mr Baumé eftabli- fhes the exiftence of the reciprocal affinity, fuch as the decompofition of ammoniacal muriate by chalk, and of calcareous muriate by *concrete volatile alkali*, come properly under the double affinities ; as fhall be fhown when we treat of thofe falts.

All that now remains to be faid on chemical attrac- tion is, to give fome account of the different opinions which have been advanced by philofophers concerning the caufe of this force *.

The firft who attempted to form a theory on this fubject, thought that it muft arife either from the ele- mentary particles of bodies being all of the fame form, or from the phyfical configuration of the parts, or laftly, from fome occult relations of their intimate com- pofition. Thefe notions proceeded naturally from the mechanical explanations which were applied to all the phenomena

* That beautiful general fact, *that all particles of matter, which are fufceptible of union by chemical affinity, continually tend to form bodies of a polyhedral, conftant, and determinate form;* appears to have been fuffici- ently afcertained by *Linnæus*, M. Romé de Lille, and the Abbé Hauy; to deferve a place among the laws of chemical attraction—H.

phenomena of nature, in the infancy of the science of natural philosophy.

Most of the modern chemists who have attempted to explain the cause of chemical attraction, have observed a remarkable analogy between this force and the general attraction discovered by Newton. Considering nature as simple and uniform, they have been led to conclude, that the power possessed by bodies of entering into mutual union, must depend on the same general laws as that by which all bodies are attracted towards each other. They have compared the minute bodies on which the force of affinity acts, with those enormous masses which compose the system of the universe; and have ventured to affirm that it is the force of gravitation which causes the former to approach each other, and enter into combination. Several persons, adopting this opinion, but modifying it in a particular manner, have concluded, that chemical attraction was in the ratio of the gravity of bodies, and that those bodies which were of the greatest specific gravity possessed always the strongest affinities. This hypothesis is sometimes indeed justified by facts, and agrees with the affinities of many of the acids; but is contradicted by the phenomena of a vast number of decompositions, particularly of all those in which metallic substances are concerned. Some chemists have been even so strongly persuaded of the existence of an analogy between the attraction of large bodies and chemical attraction, as to imagine it possible to measure and calculate the former in consequence of our knowledge of the latter. M. de Morveau, whose opinions are likely to have considerable weight with other chemists, has made a num-

ber

ber of experiments with a view to prove the
the above affertion.   Applying to a furface of ı
plates of metal of the fame diameter, fufpended ı
arm of a balance, the other arm of which carrie
he next put weights into the difh fufficient to ·
plate of metal over the mercury; and he actuall
by making comparative trials of different meti
thefe adhered to the mercury with different de
force, proportioned to the affinities known t
between them and that fubftance.   Gold adhe
the greateft force to the mercury, a greater we
ing neceffary to raife it than to raife any of t
metals : Cobalt, again, which is known to have
nity with mercury, feemed to have no adhef
that furface, and was elevated above it with the
eafe.   But we muft ufe the freedom to obfer
from feveral circumftances, fuch experiments
but be in fome degree fallacious : the inferior
of the fmooth plates of metal applied to the n
cannot but combine with that fubftance ; an
malgam formed by this event being more or
cording to the eafe or difficulty with which tl
unites with the mercury, this combination incre
weight of the plate, and renders a greater ı
quifite to raife it above the mercury.   A plate
tal adhering to a furface of mercury, cannot t
above it without dividing the mercury into ·
ers ; fo that the force neceffary to raife this plat
ployed rather in overcoming the mutual adhe
the particles of the mercury, than in dividing t
cury from the metal.

It muft be acknowledged then, that if ¢

ʁ'

attraction be the fame with general attraction ; yet
the difference of the laws by which thefe two for-
ces are regulated, proves the former to be a parti-
cular modification of the latter.   This truth becomes
evident from a comparifon of thofe laws of the New-
tonian attraction with which we are acquainted, with
the general facts relative to chemical attraction which
have of late been difcovered: The former acts only
upon large bodies, and in the direct ratio of their
maffes ; the latter affects only minute bodies, and
has abfolutely no influence on fuch as are of any con-
fiderable bulk.   Attraction acts between bodies pla-
ced at an immenfe diftance from each other: affinity
never acts but between bodies in mutual contact.   In
defcribing the laws of chemical attraction, we have
laid before our readers the facts on one fide of this
comparifon : and we are induced to conclude, that
the phenomena which thefe two great laws pre-
fent, are ftill fo ftrikingly different, as to render it
highly proper for philofophers to diftinguifh between
them *.

C H A P.

* I cannot help obferving here, that the only true and precife defi-
nition of chemiftry ; and which, fo far as I know, has hitherto been
given by no writer or lecturer on that fubject; is the following; CHE-
MISTRY IS THAT SCIENCE WHICH INVESTIGATES THE MODIFICATIONS
OF THAT ATTRACTION WHICH TAKES PLACE ONLY BETWEEN THE
MINUTE, COMPONENT PARTICLES OF BODIES.—H.

C H A P. IV.

Concerning the Principles of Bodies.

IT has been the opinion of philofophers in all age
that notwithftanding the vaft diverfity of the b(
dies of nature, they are all compofed of a few primar
fimple fubftances; and to thefe they have given th
name of *Principles.* The analyfes of chemiftry, whicl
afford the ftrongeft facts in proof of this doctrine, hav-
ing enabled chemifts to form pretty accurate notions
concerning the nature and differences of thofe princi-
ples ; they have admitted feveral kinds of them.
But it muft be remarked, that they have taken the
word *principles* in an acceptation different from that in
which it was ufed by the philofophers of antiquity.
Ariftotle and Plato applied the name *principles* to a
clafs of fubftances, which being of fuch fubtlety as to
efcape the obfervation of the fenfes, conftituted, as
they thought, by their union, thofe bodies of a lef:
fimple nature, and perceptible to the fenfes, whick
ftill continue to be known by the name of *elements*
Thefe are the fame fubftances which have been by o-
thers philofophers denominated *atoms*, or *monads*. But
chemifts, not prefuming to extend their fpeculation
to fuch fublime and fubtle objects, comprehend un-
der the general name of *principles*, all thofe fubftan-
ces, whether fimple or compound, which they obtain
by the analyfis of bodies. But as the principles o

bodies

bodies, when confidered under this point of view, muft
be extremely various, they have divided them into
proximate and *remote*. The firft are obtained by a
firft analyfis, and are capable of being refolved into o-
ther principles ; thus, by decompofing a vegetable
fubftance, we obtain oils, mucilages, falts, and colour-
ed particles ; all which are proximate principles of the
vegetable fubftance, and each of them may by a new
procefs be decompofed into other principles. By re-
mote principles, they underftand thofe fubftances
which, being fimpler than the proximate, enter into
their compofition. Thus, mucilage, one of the proxi-
mate principles of vegetables, affords by a new pro-
cefs, oil, water, earth, &c. and thefe are the remote
principles of the vegetable. Thefe two kinds of prin-
ciples have been alfo diftinguifhed by other names;
fuch as *principiated*, applied to the proximate princi-
ples; and *principiant*, to the remote. Thefe epithets
diftinguifh the former as arifing from the combination
of other fimple principles ; and the latter, as ferving
by their union to conftitute bodies, which though of
a lefs fimple nature, may yet become the princi-
ples of new compounds. Some chemifts, to ren-
der thefe diftinctions more juft and accurate, admit
more than two kinds of principles : They call thofe
principles which appear fo fimple as to be incapable of
farther decompofition, *primary*, or principles of the
firft order : *fecondary* principles are formed by the com-
bination of the *primary ;* the combination of the *fe-
condary* conftitutes *ternary* principles ; and thefe u-
nited in a new compofition, afford *quaternary* princi-
ples, &c.

I   Philofophers

demonstrate the existence of mercurial earth; and we have hitherto obtained no certain knowledge concerning that principle. Stahl paid great attention to combinations of earth and water, and still more to phlogiston, but has said scarce any thing of those which contain air; which Hales, nearly about the same time, discovered to act an important part in chemical phenomena.

From the days of Beccher and Stahl to the present time, chemists have made no change on the doctrine of the elements established by the philosophers of antiquity. They have followed Empedocles in acknowledging four principles, each of which they have considered as existing in two different states. 1. As free and insulated; and in this state have the atmosphere, large masses of water, fire in general, and the globe viewed as one whole, been considered: 2. As combined; and then the air, water, and earth obtained by the last analytical operations that can be performed on bodies, are the subjects of inquiry.

Such nearly were the opinions concerning the principles and elements of things that prevailed from the time of Beccher and Stahl, till the noble discoveries of Priestley and Lavoisier, concerning fire, air, and combustion, exploded these, to make way for others better founded. In fact, if immutability of properties, unity and simplicity, be the genuine characteristics of elements, and if this simplicity of character belong only to such bodies as we cannot reduce by decomposition, it is to be remarked, 1*st*, That of the four elements there are two, air and water, which art has at length found means to decompose and separate into several principles, 2*dly*, That elementary earth is merely the

creature of fancy ; as there are a variety of earthy i
ftances all equally fimple and imcapable of decomp
tion, as fhall be fhown in the laft chapter of this
part : 3*dly*, That there are many natural bodies, f
as fulphur and the metals, which no art has yet b
able to decompofe, and which muft therefore, in
prefent ftate of our knowledge, be confidered as fim
fubftances.

From thefe general confiderations, arifing from fi
which fhall be-more particularly related in the follc
ing chapters, and through the feries of the work, it
pears, that the true principles, or primary element
natural bodies, efcape the obfervation both of our fei
and of thofe inftruments which we employ to aid i
imperfection of our fenfes : that many of thofe fi
ftances which have been called elements on account
their bulk, their influence on the phenomena of natt
and their being found to exift in many of its prod
tions, are far from being fimple and unchangeab
and that, in truth, none of the bodies with which
are acquainted, is a fimple fubftance, though we n
afcribe this character to fuch as we have not hithe
been able to decompofe. And thefe affertions entir
agree with the opinions of fome antient philofoph
who confidered not the elements as the fimpleft of fi
ftances, but believed them to be formed of princij
infinitely more fubtle and immutable.

What we advance concerning thofe fubftances wh
have for fo many ages enjoyed the exclufive title of e
ments, but are now divefted of that prerogative, does i
hinder us from confidering fire, water, earth, and air,
forming the component principles of moft natural bodi

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Let us difmifs this fubject with an account of the terms which have been employed by fome perfons to diftinguifh bodies, according as their compofition is more or lefs complex.

The combination of two elements forms a body that is called a *mixed;* the union of feveral mixeds conftitutes a *compound;* two compounds make a *furcompound;* the combination of furcompounds gives a *decompound;* two or more of thefe united make a *furdecompound.* It would be difficult to give inftances of thefe feveral kinds of compofitions; we could indeed go no farther than to the furcompound. Thefe diftinctions are, therefore, merely fanciful, and can be of no real ufe in fcience. Macquer, to whom chemiftry is much indebted for the prefent perfpicuity of its doc-trines, propofes to explode this barbarous and inaccurate nomenclature, and to adopt in its room, Firft, Second, Third, and Fourth Order. We might even purfue the fame thought, fo far as to adopt thefe names to dif-tinguifh principles according to the order of the analyfis by which we obtain them.

C H A P. V.

Of Fire.

THOUGH we cannot agree to receive the word *ele-ment* in the fame fenfe in which it was general. underftood till the prefent time; though we can confider thofe four bodies, commonly called *the four ele-ments*, as the firft principles of all others, and the fim-pleft productions of nature; yet we are willing to inqu ire into their nature before proceeding to others; becaufe a knowledge of their properties is neceffary to enable the reader to underftand our account of the properties of other fubftances, and becaufe they cannot be arranged under any of the divifions of natural hiftory, being con-fined to no particular departments in nature, but ex-tending equally through all.

None of the four elements difplays greater activity or fimplicity than *Fire*. The more ancient philofo-phers, who in this particular have been uniformly followed by their fucceffors, gave this name to a fub-ftance which they fuppofed to be fluid, active, penetrat-ing, confifting of particles actuated by a lively and in-ceffant motion, and the firft principle of all fluidity and motion. Whoever confiders this fubject, muft readily perceive, that it was merely by conjecture they afcrib-ed thefe properties to a particular elementary body: for though the exiftence of the other three elements have always been undeniably eftablifhed, yet the exif-

tence of this has never been demonſtrated. There is reaſon to think, that in all languages, and among all nations, the firſt uſe of this word was to denote the impreſſion which hot bodies make upon the ſkin; and that it is ſignificant of the light which iſſues from bodies in combuſtion, as well as ſynonymous with the word *heat.* Many have conſidered it in this view, admitting the exiſtence of fire only where heat is felt or combuſtion carried on. Chancellor Bacon was among the firſt that began to doubt the exiſtence of fire as a particular fluid; and obſerved, that natural philoſophers, in defining it, had always miſtaken a property for a ſubſtance. Boerhaave, whoſe Treatiſe on Fire will be ever regarded as a maſterpiece, was ſenſible of this difficulty; and in order to diſcover the properties of this pretended element, examined what effects it produces on thoſe bodies in which it is believed to exiſt; ſo, like former philoſophers, he has rather given the hiſtory of hot, luminous, rarefied, and burning bodies, than of fire. This difficulty muſt ever continue to perplex the philoſopher. The properties of fire cannot but be intimately connected with thoſe of the bodies on which it acts; we can form no idea of it as exiſting in a ſeparate ſtate. Notwithſtanding the preſent advanced ſtate of chemiſtry, the exiſtence of this ſubſtance is ſtill undetermined. Philoſophers continue to believe in its exiſtence, but are able to give a ſatisfactory explanation only of its effects. Theſe difficulties have induced ſeveral chemiſts, among whom was the celebrated Macquer, to conſider fire as being nothing more than light, and heat as a certain modification of bodies, produced by the motion and colliſion of their component particles. But this

opinion no longer prevails among thofe who culti
chemiftry. In order to enter into the feveral the(
which have of late been advanced concerning fire,
muft confider it in a more particular manner. To
quire an accurate knowledge of this matter, an(
comprehend that immenfe feries of facts which at
fent conftitute the body of the fcience of chemiftry.
muft make a methodical divifion of our fubject, exar
and difcufs with pains its feveral parts and fubdivifi
and confider in fucceffive order, as fo many diftinct
fects of fire,—light, heat, rarefaction, the changes
duced on bodies by heat, and the particular qual
afcribed to fire in a ftate of combination, when it
tains the name of Phlogifton, &c.

§ I. *Of Light.*

THE exiftence of light is not doubtful, like th
fire: both its exiftence and its properties are at p
well known. This body, which is thought t(
from the fun and the fixed ftars, is the principle
enables the organs of fight to inform us of the p
of other bodies. Without it we fhould be inv
perpetual darknefs, and our eyes would be
ufelefs. Being reflected in right lines from the
of thofe bodies on which it falls, it ftrikes th
fuch a manner as to paint on the retina the
thofe objects from which it is reflected. N
been found to collect its rays in a darkene(
in fuch a manner as to render their propertie
examination, by exhibiting them diftinct f
dies which they illuminate.

The motion of light is fo rapid, that it paffes through the fpace of eighty thoufand leagues * in a fecond of time, according to the moft eminent aftronomers. It moves in a rectilinear direction, and confifts of rays, which, after iffuing from the ftars, feparate and diverge in obedience to the impulfe originally communicated to them. Such is their elafticity, that when they fall on a furface capable of reflecting them, the angle of their reflection is nearly equal to that of their incidence; as is feen in the ftudy of catoptrics. When light paffes near any body, it is more or lefs inflected towards that body; which inflection, by evincing its gravitation, fhows it to be a diftinct fubftance.

However great its fubtlety and velocity, yet it does not move invariably in a right line. Such bodies as meet and obftruct its paffage, caufe it to deviate from its original direction. When paffing obliquely out of a rare into a denfe medium, it is refracted like any other folid body; but Newton † difcovered its refrangibility to be directly contrary to that of other bodies. Other bodies recede from the perpendicular line whenever they pafs into a denfer medium; but light, on fuch an occafion, approaches nearer to the perpendicular. To explain the laws of the refraction of light is the province of dioptrics.

When light reaches the furface of the earth, it difcovers to animals the prefence of material bodies, and enables them to diftinguifh them into opaque, tranfpa-

* Twenty-five of which make a degree; equal to 167,000 geog. miles.——H.

† We owe the firft accurate account of thefe phenomena to D Cartes.—H

rent, and coloured· Its prefence is fo neceffary to re
der thefe properties perceptible, that in darknefs bod
become totally undiftinguifhable. Difference of opa
ty, tranfparency, and colour in bodies, depends, the
fore, on the manner in which they are affected by lig
or in which they affect this fubftance. A body is tra
parent when the rays of light pafs eafily through :
which depends no doubt on the form of its pores.
many tranfparent fubftances have great hardnefs a
fpecific gravity, the particles of light which penetr.
through them muft therefore be extremely fubtle.
the particles of light pafs through thofe fubftances, th
are refracted in the ratio of their denfity, if they
ftones, falts, or vitreous fubftances : but tranfpare
bodies of the combuftible clafs reflect the particles
light in a different ratio. Thus,- yellow amber ha
much greater refringent power than a faline cryfta
equal denfity.

By examining the various refractions and reflecti
of light, the great Newton was at length enabled
decompofe, or rather to diffect, this body, fo far as
difcover that the rays which compofe a beam of li
were each of a peculiar colour. ' Before him men's i
tions of the caufe of colours were very obfcure and i
diftinct. The refraction and reflection ·of each ray
light are determined by particular laws ; and theref(
when a ftream of light is directed fo as to fall on the a
gle of a triangular glafs prifm, and the prifm is turn
round on its axis ; the rays which compofe the ftre:
of light being refracted according to different laws, :
feparated in paffing through the glafs, and if recei
on a plane white furface, form a long fpectrum, c

fifting of the feven following colours ; red, orange, yel-
low, green, blue, purple, and violet.

The furfaces of opaque variegated bodies produce
the fame effects as the prifm on light. Such feems to
be the caufe of that diverfity of colours which confti-
tutes fo confiderable a part of the beauties of nature.
When all the rays which fall upon any opaque body
are reflected, without fuffering any abforption or fepa-
ration by that furface, they ftrike our eyes with all
their luftre, and the colour produced is a white : But
again, if the fame rays fall on a furface by which they
are all abforded, the eye then beholds a deep fhade;
which being a direct contraft to the former, conftitutes
black, or rather abfolute negation of colour. In fhort,
as every beam of light confifts of feven different co-
loured rays, of various degrees of refrangibility, what
diverfifies the colours of natural bodies is the various
difpofition of the particles of their furfaces ; fome of
which reflect one ray, abforbing all the reft, others
another, and fo on. Colour depends, therefore, on the
nature of the furfaces of bodies, and tranfparency on
the form of their pores ; and both are occafioned by
the modifications produced on light, either by the fu-
perficies or the interior parts of the bodies on which it
falls. A blue or red colour is produced by the decom-
pofition of a beam of light, and the abforption of all its
rays, excepting the blue or the red.

Thefe are the chief properties of light, when confi-
dered in a free ftate, or as it iffues from the fun and
the fixed ftars. But are we to examine it only in this
free and infulated ftate ? Is not this body, as well as
all the reft with which we are acquainted, fubject to

the

the laws of chemical attraction ? The phenomena ‹
light are not confined to the modifications which it fu
fers from the furfaces of bodies. Subftances expofed
its influence, by being immerfed in its ftreams, oft‹
fuffer an alteration and entire change of nature, withc
any other known caufe ; and it is reafonable to thir
that fuch changes are produced by the operation of lig
which is enabled to effect them by being capable of c¥
mical attraction.   Art, indeed, has not yet been at
to determine whether thefe alterations be occafioned 1
the decompofition of light, or by that of the bodies .
contact with it, or by the mutual decompofition of botl
which laft is highly probable : but they are too num‹
rous and too ftriking to be paffed over unnoticed. W
fhall here mention only a few of the moft remarkable
becaufe our attention will be more particularly turne
towards this object in the hiftory of natural bodies.

Naturalifts have long obferved the influence of ligb
on vegetation.   Thofe engaged in the cultivation c
plants firft obferved, that fuch as grow in the fhade ar
of a paler colour.   This phenomenon has received th
name of *ætiolation* ; and the plants on which it takt
place are faid to be *ætiolated*.   Herbs growing und‹
ftones are white, foft, aqueous, and infipid.   Garder
ers take advantage of this circumftance to fupply oı
tables with white and tender herbs and pulfe; for the
bind their leaves fo clofely together, that the exterir
defend the interior from the contact of the light. Tl
colour of herbs is pale or deep in proportion as they aı
lefs or more expofed to the rays of the fun ; and in coı
fequence of this, the nations of the eaft obtain from tl
wood, bark, or roots of trees, many of the moft valu-
                                                         t

ble colouring ſtuffs, both for permanency and luſtre, which all the ingenuity of European dyers has never been able to imitate.

Colour is not the only property that vegetables derive from the influence of light. From the fame ſource they acquire taſte, ſmell, and combuſtibility. Thus light contributes to the ripening of fruits and feeds; and under the torrid climate of America, vegetables in general are highly odorous, ſapid, and reſinous, &c. Laſtly, light exerts ſo powerful an energy on the organization of vegetables, that when the rays of the ſun fall upon them, their leaves pour from their ſuperior pores copious ſtreams of vital air; but when hid from the influence of that planet, they exhale a deleterious mephitic, or rather a real acid, of the fame nature with that which is extracted from chalk. This important diſcovery was firſt made by Dr. Prieſtley. M. Ingen-houſze has proſecuted it much farther; and from the experiments and obſervations of both, it appears how powerful the influence of light is on vegetation. In a great number of chemical operations, light is found to act with the fame energy as in thefe more general inſtances. There is not one ſubſtance in nature, that, if put into a cloſe glaſs veſſel, and expoſed to the rays of the ſun, will not ſuffer ſome alteration from their influence. Theſe alterations are moſt remarkable in mineral acids, oxides, or metallic calces, vegetable powder, and volatile animal oils. Not a ſingle metallic oxide, though more eſpecially that of mercury, but ſuffers a change of colour, aſſuming generally a deeper ſhade from being expoſed to the rays of the ſun. Painters' colours which are kept by merchants in glaſs bot-

tles,

tles, afford a good inftance of this.   Mineral acids ex-
pofed to the fun become fuming, higher coloured, and
more volatile; metallic falts become black; animal oils
affume a brown dufky colour.   All thefe changes merit
the moft careful attention of chemifts; they afford vaft
fcope to refearch, and have not hitherto been obferved
with fufficient care.   Scheele was the firft who defcrib-
ed any of them.   M. Berthollet has alfo turned his views
to this object; and we fhall afterwards fee that he has
determined accurately what paffes in many of thefe al-
terations.

§ II.   *Of Heat.*

To examine the properties of heat is a much more
difficult tafk than to examine thofe of light.   Bodies
when heated acquire no additional gravity; which might
ferve to prove that heat is a diftinct fubftance.   Bacon,
and many other great men, have thought heat to be
only a certain modification of which bodies are fufcep-
tible.   It is certain that natural philofophers, as well as
other men, have always confidered its prefence as a
fure indication of the prefence of fire; have fometimes
confounded it with that element; and fometimes confi-
dered heat as one of the diftinguifhing properties of fire.

Its leading properties are, to penetrate through all
bodies; to diffufe itfelf equally, and to tend to an equi-
librium; to dilate all fubftances into which it infinuates
itfelf, caufing them to pafs from a folid to a fluid ftate,
and from this to affume the form of elaftic fluids.

Heat is ufually communicated to bodies in one or
another of thefe three ways; by contact, by motion, or

by

by combination. Every perfon muft have obferved, that when two fluids different in temperature, the one fenfibly warm, and the other fenfibly cold, are mingled together, the former lofes part of its heat, which is communicated to the fecond, fo that the temperatures of both become the fame. It is equally well known, that when two folids, the one warm, the other cold, approach each other, the latter robs the former of part of its heat, and the temperatures become equal. As to the calling forth of heat by motion; the friction of any two folid fubftances, fuch as two hard ftones, two pieces of wood, ivory, or metal, produces a heat which often rifes to inflammation. The production of heat by combination is no lefs undeniable. The union of concentrated acids with water, quicklime, pure alkalis, or metals, is productive of a ftrong heat: the combination of certain fluids, fuch as oil and fpirit of nitre, is even fo powerful this way as to caufe inflammation.

The laws of the communication of heat were confidered as analogous to thofe of motion, till the labours of Meffrs Black of Edinburgh, Wilcke of Stockholm, Irvine of Glafgow, Crawford and Kirwan of London, and Lavoifier of Paris, gave us new and more accurate ideas on the fubject. The refearches of thefe philofophers have fhown, that nothing was lefs known, or involved in greater difficulties, than the progrefs and communication of heat among bodies unequally heated. Their experiments, though highly ingenious, are not yet fufficiently numerous. They themfelves do not prefume to confider their obfervations as of fufficient weight to form an elementary part in the fcience of chemiftry: But it is highly probable that thefe will lead

to

to the eftablifhment of a general theory, which may
applied to all the phenomena of chemiftry; in eve
one of which heat acts a part, by either its abforptic
or difengagement.

Even the niceft and moft accurate obfervations ha
been hitherto infufficient to afford us any determina
ideas of the nature of heat; and both chemifts and n
tural philofophers are ftill divided in their opinions
this fubject. Part follow Bacon of Verulam, in con
dering heat to be nothing more than a modification
which all natural bodies are fufceptible; which has 1
feparate exiftence, but confifts in the ofcillation of tl
minute particles of bodies. This was Macquer's oj
nion. The philofophers who maintain it, fupport
on the following facts. Heat accompanies all the ph
nomena of motion, and appears fubject to the far
laws: It is increafed with the increafe of motion, a
diminifhed by its diminution. Excepting its comm
nication or paffage from one body into another,
which it follows laws different from thofe of motio
in all other refpects there is a ftriking analogy betwe
the two; and when this caufe acts with lefs force,
entirely ceafes to act, heat is inftantly diminifhed, a
foon totally loft. To explain this hypothefis, the pl
lofophers by whom it is maintained obferve, that ev
bodies of the greateft denfity are full of fmall caviti
or pores, the fum of which if they were taken togeth
would perhaps occupy a larger fpace than the fol
matter of the body that contains them. Thefe vc
fpaces afford room for the particles to move one agai
another in a continual ofcillation. The ofcillations a
not obferved, becaufe both the particles and pores a

so subtle and minute as to elude our senses. Lastly, The philosophers who regard heat as an internal motion, urge that no experiment has hitherto demonstrated its existence in a separate state, and that it makes no addition to the gravity of bodies, &c.

On the contrary, many other philosophers, and some modern chemists, are of opinion, that heat is a particular fluid, diffused through all nature, of which every body contains more or less. They distinguish this fluid as existing in two different states,—in combination, and at liberty. In the former state, it neither affects our senses nor the thermometer, but remains quiescent in those bodies of which it constitutes a principle; it is then more or less in a state of confinement. In the decomposition of the bodies it is often disengaged, and escapes into a state of liberty: it now becomes capable of acting on bodies exposed to its influence; and its force is measurable by a graduated thermometer. As all bodies that pass from a solid to a fluid state, and thence into a vaporous form, excite cold in the surrounding atmosphere, they suspect that such bodies absorb a great quantity of heat; and when fluids, by assuming a concrete form, generate heat, they think that heat is then disengaged from those substances, and passes from a state of combination into a state of liberty.

Scheele, as well as Bergman, being persuaded that heat is a distinct substance, has examined with great attention all the phenomena which it displays as a chemical agent susceptible of combination. He has even thought himself warranted by his experiments to conclude, that it is a combination of vital air, which he calls *empyreal fire*, and fixed fire or phlogiston, and

dif

differs from light only in the relative quantity of the laft principle. But however ingenious and accurate his experiments, the inductions which he has drawn from them concerning the nature and principles of heat, do not appear to be naturally deducible from the facts; and we cannot confider his analyfis of heat as fully demonftrated to be juft. Some philofophers are of opinion, that light and heat are the fame fubftance, only exifting in different ftates. This fubftance becomes light, when its particles being collected together, and poffeffing all their attractive force, are violently darted to a diftance: it affumes the character of heat, when the fame particles exift in a ftate of divifion, move gently, and tend towards an equilibrium. Heat may be converted into light, and light again into heat. It muft be acknowledged, however, that light often produces effects very different from thofe of heat; as on the nitric acid, the oxigenated muriatic acid, the calces or oxides of metals, and the leaves of vegetables dipped in water; all which bodies afford vital air or oxigenous gas when expofed to the rays of the fun, which can be obtained from fcarce any of them by the operation of heat. Thus the artificial light of our fires paffing through veffels, changes the nature of the products which it difengages. Laftly, Meffrs Lavoifier and De la Place feem to think both thefe opinions true: they confider heat as a diftinct fubftance, which by its prefence in natural bodies occafions an ofcillation of their component particles.

But though the nature of heat be not certainly known, the phenomena to which it gives rife in chemical combinations and decompofitions are not the lefs

certain

certain on that account, and are worthy of careful ob-
fervation. It appears from a vaft variety of facts, that
whether a body or a modification, it is of itfelf liable to
no alteration, and is never loft; and the confideration
of this has induced Meffrs Lavoifier and De la Place to
form an axiom or general principle concerning its ap-
-pearance or difappearance. As that axiom is of the
higheft confequence, we fhall infert it here.

" If in a combination, or in any change of ftate
whatfoever, there be a diminution of free heat, the
whole of that heat will again appear when the fubftan-
ces are reftored to their former ftate; and on the con-
trary, if in any combination or change of ftate there be
an increafe of free heat, this additional heat will dif-
appear when the fubftances return to their original
ftate."

They generalize this principle ftill farther, fo as to
make it extend to all the phænomena of heat; and
they then exprefs it in the following terms. " All the
variations of heat, whether real or apparent, that any
fyftem of bodies can fuffer, are reproduced in an in-
verfe order when the fyftem returns to its original
ftate."

In order to meafure the quantity of heat that is ab-
forbed or difengaged in the various phenomena of che-
miftry, which appears from what has been faid, to be
an object of the higheft importance; modern philofo-
phers have endeavoured to find means for correcting
the obfervations of the thermometer, and extending its
fcale. M. Wilcke propofed to eftimate the heats of bo-
dies by obferving what quantities of fnow they could
melt in a given time. Meffrs Lavoifier and De la Place

have contrived a method which is more certain and moi
eafily practicable; reducing fubftances that produce he
by their combination, as well as the veffels in which the
are contained, to the temperature of 32° Fahrenheit
they then put them into a veffel laid round with ice
and as the interior furface of the ice cannot be melte
but by the heat which is difengaged while the fubftan
ces are entering into combination, the quantity of th
heat thus difengaged may be meafured by the quantit;
of the water obtained by the melting of the ice, whie
muft be carefully collected *. By this procefs the;
have been able to eftimate the fpecific heats of variou
bodies, to meafure the quantity of heat abforbed in va.
rious combinations, and even to determine how much
is difengaged in combination and refpiration. We are
obliged to refer our readers to the work of thofe learn-
ed academicians themfelves, for an account of this in-
genious inftrument, and the manner in which it is to
be applied to the varions purpofes for which it is adapt-
ed; as the detail of particulars neceffary to explain it
would be inconfiftent with that brevity which we mean
to follow through the courfe of this work †.

Here let us confider more particularly the refem-
blance that appears in fome inftances between light
and heat, as well as thofe peculiarities by which they
are diftinguifhed from each other in the operations
                                                both

* We underftand from the Philofophical Tranfactions, that in fome
attempts made by an ingenious Englifhman, it was found that eves
this method may be fallacious.—H.

† See a Memoir on Heat, read before the Royal Academy of Sci-
ences on the 28th of June 1783, by Meffrs Lavoifier and De la Place
of that Academy.—F.

both of nature and art. Though the light of the fun's rays warm thofe bodies on which it falls; yet we muft not conclude from this circumftance that light and heat are the fame; there are a great many inftances in which light is totally deftitute of heat, and others again in which heat is not accompanied with light; and a number of philofophers therefore confider them as effentially different. In fact, phofphori, diamonds, putrid wood, animal fubftances in a ftate of putrefaction, luminous infects and worms, as well as the rays of the moon, concentrated on metallic mirrors or lenfes, afford a ftrong fparkling light, but no fenfible heat; and all the bodies in nature may be ftrongly heated without becoming luminous.

The rays of the fun appear to produce heat merely by their impulfe on the bodies on which they fall, or by the friction which they fuffer from thofe through which they pafs. Red, and more particularly black opaque bodies, are fooner heated than white, bright furfaces; doubtlefs becaufe they refract the rays more powerfully, and perhaps even becaufe light enters into combination with thofe high-coloured fubftances, while white furfaces do not abforb, but reflect the rays which fall upon them.

With regard to the production of light by a ftrong continued heat, as in the combuftion of oils, wood, or greafe, and the ignition of metals and ftones; this may alfo be accounted for without allowing the indentity of light and heat. When combuftible bodies are ftrongly ignited, they at length produce flame; which has the fame effects as the rays of the fun, and fupplies their abfence. But this light which is produced by inflam-

mation, may have before fubfifted either in the com
buftible body or in the air, the prefence of which i
neceffary for its production : and this fact, therefore
affords no proof that heat may be changed into light
The ignition of incombuftible bodies, fuch as ftones, ii
which light cannot fubfift in a combined ftate, not a
leaft in the fame manner as in combuftible bodies, ha
been very ingenioufly explained by Macquer. In hi
opinion it depends on the ftrength of the vibration
communicated to the particles of thofe bodies by the
impulfe of heat. Thofe vibrations difpofe the particle
in fuch a manner, that their facets, acting like fo many
little mirrors, reflect upon our eyes the rays of light,
which exift in the air by night as well as by day ; for
we are involved in darknefs during the night, for no
other reafon but becaufe thefe are not then fo directed as
to fall upon our organs of fight.

Such were the notions of Macquer and of many other
philofophers. But a very numerous feries of accurate
facts concerning the differences of heat in bodies, the
capacity of bodies to abforb it, and the elective attrac-
tions to which it is fubject, render the exiftence of heat
as a diftinct body much more probable than ever. It is
thought to be often a principle in compound bodies, and
the lighteft of all the fubftances in nature ; and this laft
property is confidered as the reafon why we cannot de-
termine its exiftence by its weight. Heat is diftinguifh-
ed into two kinds, or rather as exifting in two differ-
ent ftates ; in the one, it is intimately combined with
other principles, and is denominated *latent heat,* or
the *caloric* principle, becaufe it is not perceptible to
the fenfes ; in the other, it is only diffufed without com-
binatino

bination. This laſt kind of heat may be expelled by preſſure : thus, when a bar of iron is ſtruck, the ſtroke compreſſes its particles and cauſes the heat to iſſue out, in the ſame manner as water iſſues from a wet ſponge when it is preſſed together with the hand. Combined heat cannot be ſeparated from the bodies of which it forms a part, but by means of new chemical combinations. All ſolid bodies that contain any portion of theſe two kinds of heat, are capable of receiving more of both. When you add a quantity of the ſecond ſpecies to any body, its firſt effect is to enlarge the pores that ſeparate its component particles, by which means it ſoftens a ſolid ; next, as it gradually accumulates, it produces fuſion or liquefaction ; and as the quantity of heat continues to increaſe, elaſtic fluidity follows : But we ſhall treat of theſe phenomena in the two following ſections.

§ III. *Of Rarefaction.*

RAREFACTION is the moſt remarkable of all the effects which philoſophers aſcribe to fire, and is conſtantly produced by heat. We have already taken notice that the chief effect of heat is to diminiſh the ſpecific gravity of bodies, by extending their bulk, without adding any thing to their abſolute weight. This rarefaction ſhows, that ſome new ſubſtance is introduced into the cavities of the rarefied body. This ſubſtance, which is no other than heat, acts in proportion to the interſtices which ſeparate the component particles of the body. Bodies when rarefied by heat gain no additional weight, and have their ſpecific gravity diminiſhed

ed ; becaufe rarefaction confifts fimply in the feparat
of the parts of the warm body, its pores being enlarg
fo that there is more vacuity and lefs folid matter tl
before in a given fpace. This feparation of parts is
fected by heat, which is to us, in point of weight,
mere non-entity.

When we confider, that the particles of bodies ra
fied by heat, fuffer an internal motion, which tends
divide them from one another; and that cold, on t
contrary compreffes and condenfes them ; we are l
to confider heat as a force oppofed to the mutual g
vitation of thofe particles, which weakens their pa
cular attraction : For it is to be obferved, that th
are three modifications of the Newtonian attracti
which ought to be carefully diftinguifhed from one a
other. The firft ftate of attraction is that which
operates with a primary impulfe to retain the plan
in their orbits, preventing them from approaching t
fun, upon whom they would foon fall were it not :
the centrifugal force which they have received fr
primary impulfe ; this may be called *planetary attr*
tion, to diftinguifh it from the other two. The feco
ftate or modification of attraction is that which cau
bodies projected into the atmofphere of our globe
tend towards the centere : this is *terreftrial gravitati*
The third modification of this general force is that
which the feveral parts of any body tend to their co
mon centre : fuch as a ftone or any other confift
body : this force produces aggregation, and in its '
rious degrees is the caufe of fpecific gravity : It is t
laft fpecies that heat diminifhes and tends to annihilat
and by acting in oppofition to this force, it produces
                                                    infini

infinite variety of effects in combination, decompofition, vegetation, animalization, &c.

Boerhaave, who has examined the effects of fire rather as a philofopher than a chemift, has eftablifhed three general laws concerning rarefaction, which we fhall examine.

FIRST LAW.

All bodies are dilated by heat.

THOUGH it be a general truth, that heat dilates and rarefies almoft all natural bodies, yet we may make a few remarks on this phenomenon. Firft, all mineral fubftances without exception are dilated and rarefied in the direct proportion of the ftrength of the heat to which they are expofed. This rarefaction may even be carried fo far as to deftroy the aggregation of many among them ; but vegetable and animal fubftances af-ford fome exceptions to this law. A gentle heat in-deed dilates their fibres, divides them, and thus dimi-nifhes their confiftency ; but a fudden ftrong heat cau-fes parchment, membranes, and tendons, to fhrink and contract their bulk ; which feems to be occafioned by the irritability, or more properly the contractive force, of animal fibres, on which heat appears to act as a fti-mulus, till their organization be deftroyed.

SECOND LAW.

All the dimenfions of bodies rarefied by heat, are dilated.

A BAR of iron ignited becomes both longer and thicker. Philofophers have contrived feveral inf

G 3

which are ftill but very imperfectly known, it is c
importance to know, 1. That bodies always produc
cold when they pafs from a folid to a fluid ftate ; as to
inftance, falts when diffolved in water, evaporatin
æther, &c. 2. That fluids capable of affuming a con
crete form, generate heat as they become folid : thu
water, which freezes when put into a freezing mixture
never affords fo high a degree of cold as fpirit of win
put into the fame mixture.   It may be underftood fror
what has been faid, that when a folid body becomes li
quid, it abforbs an additional quantity of heat ; an
when a liquid body becomes folid, part of the hea
which it contained is difengaged.

§ IV.   *Of the Phlogiston of Stahl.*

BECCHER, ftruck with that property of certain bo
dies whith enables them to produce fire, that is t
fay, light and heat, in confequence of continued mo
tion, or by coming into contact with other bodies i
a ftate of ignition, imagined it to depend on a diftin(
principle, to which he gave the name of *inflammabl*
earth. Stahl, whofe attention was ftrongly engag
ed by this doctrine, underftood this principle to b
pure fire, or the matter of fire fixed in combuftibl
bodies.   To this element, exifting in fuch a ftate (
combination, he gave the name of *phlogiston,* or th
inflammable principle, to diftinguifh it from fire in
free or active ftate.   Its properties, when combine(
are totally different from thofe which it difplays whe
at liberty : it then gives neither heat nor light, though
in the latter ftate, thefe are its conftant attendants
                                                    Bu

But, when freed from confinement, it conftantly regains its characteriftic properties, and its prefence is indicated by both heat and light. Such was the fublime and fimple idea of Stahl concerning the nature of combufti-ble bodies. It is indeed natural to think, that thofe fubftances which, when ftrongly heated or forcibly ftruck, become inflamed, and continue to burn till they be confumed, owe this property to their latent fire; and that the combuftion of fuch bodies is nothing but the difengagement of the fire, and its paffing to a ftate of liberty. According to Stahl, therefore, all combuftible bodies contained fire in a fixed or com-bined ftate, on which principle their inflammability depended. He alfo confidered this principle as being perfectly the fame in all the fubftances into which it entered, whatever their nature, or however different they might be from one another. The combuftibility of any body appeared to him a fufficient proof that it contained a quantity of phlogifton. Thus, in his opi-nion, fulphur, charcoal, metals, oils, and phofphorus, owed all their properties to phlogifton; and their dif-ferences in point of form, colour, confiftency, gravity, &c. might depend, he thought, on the variety of the principles to which the phlogifton was united; for the phlogifton itfelf was always the fame, and could fuffer no variation but by being difmiffed from a combined into a free ftate.

In order to diftinguish the properties of phlogifton or fixed fire, Stahl inftituted a comparifon between bodies into the compofition of which it enters, and o-thers that feem deftitute of it. He obferved the for-mer to poffefs in general, colour, fmell, fufibility, vola-

dies, as he hoped, from the examination of their na-
ture, to determine the character of phlogiston, that he
feems to have forgotten that air is effentially neceffary
to combuftion. In confequence of this, he has over-
looked this objection againft his theory, which was not
indeed urged againft him by any contemporary chemift.
If combuftion be nothing but the difengagement of
phlogifton, it is plainly an act of decompofition, in
which the combuftible body lofes one of its principles
But how is it poffible for a body, after having loft one
of its component principles, to poffefs confiderably
more abfolute weight than before? An hundred lib.
weight of lead affords an hundred and ten of minium;
the weight of the fulphuric acid obtained by the com-
buftion of fulphur, is greater than that of the fulphur
from which it was obtained: and, in the fame manner
we learn from the fine difcovery of M. Lavoifier, that
eighteen ounces of pure water are obtained by burning
fixteen ounces of fpirit of wine *.

The ftrength of this objection, together with the
difficulty that is found in every attempt to demonftrate
the exiftence of phlogifton, have induced fome modern
chemifts to deny that there is fuch a fubftance in nature.
But they muft not be implicitly liftened to; even that
numerous train of experiments which have been of late
made on combuftible bodies and combuftion, have not
fully demonftrated that there is no fuch principle a
fixed fire in material bodies: its exiftence feems to be
allowed, while its name is changed; and inftead of the
phlogiftic, it is called the *caloric*, principle. It is di-
vefted

* *Meeting of the Royal Academy of Sciences on the 4th of Sep-
tember 1784.*—F.

vefted, however, of the property of producing combuf-
tion; and though it be acknowledged to exift in inflam-
mable bodies, it is not confidered as the caufe of their
inflammability.

Since chemifts began to inquire how far the pre-
fence of air is neceffary to combuftion, they have made
feveral important difcoveries; the chief of which is,
that a certain quantity of atmofpheric air is always ab-
forbed by burning bodies, and that it is the acquifition
of this air, which becomes fixed or combined, that
augments the abfolute gravity of metals, fulphur, phof-
phorus, inflammable gas, and fpirit of wine, when ex-
pofed to combuftion. As this increafe of gravity has
been likewife found to correfpond precifely with the
weight of the air abforbed, feveral chemifts, at the head
of whom may be reckoned Meffrs Lavoifier and Buc-
quet, were led to adopt a new theory, founded folely
on this abforption of air, in which they entirely rejected
phlogifton. This theory was directly oppofite to Stahl's,
and confifted of the four following principles:

1. Stahl's phlogifticated bodies are, according to this
doctrine, fubftances which have a ftrong tendency to
combine with air; for on this tendency the combuftibi-
lity of bodies entirely depends.

2. All the phenomena which Stahl afcribed to the
difengagement of phlogifton are produced by combina-
tions with pure air: fuch are combuftion, calcination,
refpiration, and the formation of the fulphuric and
phofphoric acids, by the combuftion of fulphur and
phofphorus.

3. On the other hand, according to the pneumatic
theory, all thofe phenomena in which the doctrine of

Stahl reprefents the phlogiftic principle as entering i
to new combinations, are produced by the difengag
ment of air.   Such are the reduction of metals, effecte
by the mutual action of metallic calces and charcoe
the decompofition of acids by combuftible bodies, an
particularly the decompofition of the fulphuric and ni
trous acids by iron, charcoal, &c.   ·

4. This theory views all thofe bodies which Stal
thought to be compounds, with phlogifton for one
their principles, as fimple fubftances, having fo ftron
an affinity with pure air, that they attempt to enter ir
to combination with it whenever they are expofed
its contact.   Combuftion is, therefore, nothing but th
combination of air with the combuftible body ; and
operations in which bodies are thought to regain the
phlogifton, are merely the difengagement of pure ai
or its paffing out of one body into another.

This opinion, which was adopted by M. Bucqu
in his latter courfes of lectures, explains indeed moft
the phenomena of combuftion, calcination, and the re
duction of metallic calces ; but it does not entirely explai
why flame is feen to proceed from combuftible bodi
in a ftate of ignition ; nor does it account for the rapi
motion produced in inflammation; and the other char
ges which attend this phenomenon.   Macquer, afte
carefully examining how far the modern. difcoveri
could affect the received theories, was of opinion tha
they were infufficient to explode the theory of Stah
and has therefore combined the pneumatic with th
phlogiftic doctrine, by reprefenting phlogifton as ligh
in a ftate of fixation.   After fhowing that pure ligh
fuch as that which the fun diffufes over our globe, ma

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be confidered as the fubftance of fire, and, by being fix-
ed in bodies, may actually conftitute the phlogifton of
Stahl; he next gives it as his opinion, that in every act
of combuftion, pure air difengages the light or phlogif-
ton of combuftible bodies, and poffeffes itfelf of its place;
and that the calcination of metals may therefore be re-
garded as the precipitation of air, and the difengage-
ment of light. Again, when phlogifton is reftored to
the calces of metals by reduction, light, in its turn, dif-
engages or feparates the air which was fixed in thofe
fubftances, and by that means caufes them to refume
the character of metals. Macquer alfo thought; and it
was neceffary to his theory, formed with a view to re-
concile Stahl's with the modern doctrine; that phlogif-
ton may combine with bodies even in clofe veffels,
fince light is well known to penetrate through glafs,
and even through metal and earthen veffels, when thefe
are made red-hot. Scheele has propofed a different
theory, which has alfo been adopted by fome northern
chemifts. He confidered fire, heat, and light, as com-
pounds of vital air with phlogifton; and thought that
light in paffing through veffels, fuffered decompofition,
the phlogifton in the reduction of metallic calces or ox-
ides being communicated to the calx, while the vital
air was difengaged. But this ingenious theory, by
which Scheele accounted for the effects of folar light,
and of the various modifications of heat on a great ma-
ny chemical phenomena, affords no explanation of the
increafe of the weight of metals, fulphur, and phofpho-
rus, &c. after combuftion.

M. Lavoifier, whofe experiments have contributed fo
highly to the advancement of chemiftry, and whofe o-

pinion

pinion muſt therefore have confiderable weight, ha▬
propofed a new theory that has been adopted by moſt▬
French chemiſts, and appears to me to afford an hap▬
pier explanation of the phenomena of Nature than an▬
other. He thinks that light, heat, and all the othe▬
remarkable phenomena of combuſtion, depend rathe▬
on a certain action of the air than on the peculiar n▬.
ture of combuſtible bodies; that the flame which the ▬
ariſes is occaſioned by the difengagement of the light
which was combined with the pure air, not of that
which exiſted in the combuſtible body. He afcribes to
pure air that decompoſition which, according to Stahl
and Macquer, takes place on the inflammable fubſtance.
Pure air he confiders as a compound of the fubſtance of
fire and another principle which fhall be afterwards de-
fcribed; and the fixed fire, the difengagement of which
is the principal act on fuch occaſions, is, in his opinion,
feparated from the pure air, not from the combuſtible
body. We cannot enter more particularly into this
ingenious fyſtem in this place. In the hiſtory of air, in
the following chapter, it will come more properly under
our examination. At prefent we fhall content our-
felves with obferving, that the fire or heat, which M.
Lavoifier allows as a principle of pure air, and the dif-
engagement of which he takes to be the caufe of the
fparkling flame and vivid heat which accompany the
rapid combuſtion produced by that air, act nearly the
the fame part with Stahl's phlogiſton, or Macquer's fix-
ed light; and that chemiſts feem to have univerfally a-
greed concerning the exiſtence of this principle, the
only difference among them being, that one party be-
lieve it to exiſt in combuſtible bodies, and to be the

      caufe

ufe of inflammability; while another confider it as a
rinciple of air, and afcribe inflammation to a different
ufe. In the following chapters, we fhall explain the
afons which induce us to prefer the latter of thefe
xinions.

V. *The Effects of Heat on Bodies confidered Chemically.*

In the third fubdivifion of this chapter, it was fhown
at one of the chief effects of heat is to rarefy bodies,
increafe their bulk, and diminifh their fpecific gravi-
, by feparating their particles, and enlarging their
res. Such was the fimple phyfical or mechanical i-
a which we gave when fpeaking of rarefaction in ge-
ral; but when we attend more carefully to this pri-
ury act of heat, we fhall find that it produces feveral
her important effects.
The firft and moft ftriking effect of heat, is its di-
nifhing the aggregation of bodies, by feparating their
rticles. As the force of aggregation, and that of the
raction of compofition, are always in the inverfe ra-
of one another, as has been fhown in the third chap-
; it will be readily underftood that heat, in deftroy-
; aggregation, muft be fingularly favourable to com-
ation. This has caufed fire to be confidered as the
ncipal chemical agent, and has even induced chemifts
ffume the title of *philofophers by fire.* It will after-
ds appear, however, that they make much lefs ufe
t at prefent than they formerly did.
he action of heat, when confidered in this point of
v, as tending to deftroy aggregation, and favouring
bination, appears liable to four different modifica-

ol. L   H   tions

tions, according to the nature of the bodies on wf
exerts its energy.

1. There are fome bodies on which it produce
alteration, nor any effect but dilatation.   Subftan
this nature are unalterable and *apyrous.*   Thus
cryftal, however long expofed to the utmoft violet
fire fuffers no alteration : it lofes neither its hai
nor tranfparency, and appears, after this affay, wi
its former denfity and beauty.   But there are ver
fubftances fo little alterable as rock-cryftal.

2*dly,* Heat entirely deftroys the aggregation of
bodies, caufing them to pafs from a folid to a fluid
This phenomenon is named *fufion ;* the bodies on v
it is produced are called *fufible.*   There are variou
grees of fufibility, from that of platina, which
tremely difficult to melt, to that of mercury whic
mains always in a fluid ftate.   When this fufibi
carried to an exceffive degree, it becomes volatiliz
A body becomes volatile, or diffufes itfelf throug
atmofphere, when it is caufed to pafs, by a ftrong
faction, from the liquid ftate to that of an elaftic
It is then diffipated by heat, and elevated in th
mofphere, where it remains fufpended till cold r
to it part of its denfity and fpecific gravity.   I
which may be reduced to this ftate are named *vol*
thofe incapable of it are, by way of oppofition, (
fixed.   There are many degrees between fixity and
tility.   It even feems impoffible to fuppofe any
abfolutely fixed.   Perhaps the only reafon why an
pear fo, is, becaufe we cannot apply to them a d
of heat fufficiently intenfe.   We may make the
remark on infufibility ; it is never abfolute.   Th

fon why rock cryftal appears infufible, is, becaufe we canno: apply to it the proper degree of heat. When we fpeak, therefore, of the infufibility or the fixity of certain fubftances, we are to be underftood as fpeaking only in reference to the heat to which it is in our power to fubject them.

This effential volatility is to be carefully diftinguifhed from that which is merely apparent, and takes place only in confequence of the communication of motion by a current of flame or vapours : Thus, for inftance, zink, in a ftate of calcination, is carried up by the flame that is raifed during its combuftion.

3*dly*, When heat acts on bodies confifting of two principles, one volatile, the other fixed, it generally feparates them by volatilizing the former. Such bodies are thus decompofed, but without fuffering any alteration ; for by reuniting their principles, we can reproduce them with all their original properties. This feparation of principles is a true or fimple analyfis. Fire applied to bodies confifting of two fubftances, between which there is a wide difference in refpect of volatility, reduces the volatile principle to vapours, but leaves the fixed uninjured. But in order that this true analyfis may take place, it is requifite that both the volatile and the fixed principle of the compound be unalterable by the degree of heat applied to them ; or that they be expofed only to fuch a degree of heat as they can bear without lofing any of their properties. The volatilized fubftance having then undergone no greater alteration than the fixed, they may be reunited fo as to form the fame compound which they conftituted before their feparation. When this may be effec-

ted,

ted, the analyfis is true or fimple. As bodies do 1
generally confift of two principles, one of which is 1
latile the other fixed, and as it is often extremely di
cult, and fometimes even impoffible, to apply to co
pounds of this kind precifely that degree of heat whi
will volatilize the one without alteration, and leave t
other uninjured; it may be naturally inferred, tl
the number of the bodies on which heat acts in t.
manner muft be very inconfiderable. For this reafi
chemifts have now much lefs frequently recourfe
the operation of fire than formerly. The fubftan
on which heat produces this effect are *decompof*
without alteration. Some mineral fubftances, fuch
cryftallized falts and folutions of neutral falts, coi
under this clafs.

4*thly*, When the body expofed to the action of fi
confifts of feveral volatile and feveral fixed principl
the volatilized principles enter into mutual union; tl
fixed are alfo combined with one another: and fuch
the refult of this decompofition, that though the pl
ducts be reunited with the refidues, the original coi
pound will not be produced. This is therefore a fa
or complicated analyfis. The bodies on which heat a
in this manner are *decompofable with alteration.*

Moft natural fubftances belong to this clafs. Th
are too complex in their compofition, and confift
too many principles, to be decompofed without fuff
ing alteration. As the force of the affinity of com]
fition acts upon all bodies, and is even promoted
heat, when any of the principles of a compound l
volatilized by the action of fire, they react upon c
another, unite, and form a new order of combinati
differ

different from that in which they before fubfifted : the fame thing takes place on the fixed principles of the body. Thus, when a piece of wood, bark, or any other vegetable fubftance, is expofed to the action of fire ; the water, the falts, and the oil, unite togther, and conftitute an acid, elaftic fluids, and a brown oil, &c. which did not exift in the wood in that form. The action of heat, therefore, produces a total alteration on fuch fubftances : the phenomena which attend it indicate a falfe or complicated analyfis, the refults of which might lead chemifts into miftakes were they not aware of the uncertainty with which it is attended. It is certain that art can never reproduce wood or bark, by mixing together the phlegm, oil, acid, and charcoal obtained in this analyfis, and that the principles which it affords have fuffered great alterations. Unluckily the bodies fufceptible of thefe alterations are the more numerous clafs. Under it all animal and vegetable, and moft mineral, fubftances are to be ranked. But the modern difcoveries will enable us to determine the true nature of the principles of fuch fubftances, by examining fuch of them as are difengaged.

Hitherto we have fpoken only of the effects of fuch a ftrong heat as is ufually employed in the operations of art : But a gentle and continued heat, fuch as that which is exerted in the operations of nature, gives rife to a number of important phenomena, which are highly worthy of the chemift's attention. The vibration and ofcillation of the particles of folid bodies which its impulfe occafions, and the agitation and rarefaction of fluids arifing from the fame caufe, produce a continued internal motion which gradually changes the form, the

H 3   dimenfions,

dimenfions, and the contexture, of the former; and produces a fenfible alteration on the confiftency, the colour, the tafte, and, in a word, on the intimate na-ture, of the latter. Such is the general idea which we have reafon to form concerning the exiftence and power of all the chemical phenomena of natural bodies; concerning the fpontaneous decompofition.and recom-pofition of minerals; concerning the cryftallization, the folution, the formation of falts, the vitrification, the metallization, the vitriolization, and the minerali-zation, which are carried on in the bowels of the earth. To this powerful agent we muft likewife have recourfe, when we attempt to form an idea of the alterations to which animal and vegetable fubftances are liable; of the motion of the fap in plants, and the mild fermen-tation which conducts them to maturity; of the forma-tion of oils, the fpiritus rector, mucilages, and the colouring principle; or of the compofition, the decom-pofition, the reciprocal changes, and the putrefaction of animal humours. All thefe important phenomena de-pend, more or lefs, on chemical operations; and that heat which is diffufed over the globe is the great prin-ciple by which they are produced. It is at prefent enough for us to have taken a general view of this great caufe of motion, life, and death. We have here fketched the outlines of the picture; in what follows we fhall endeavour to fill them up with a nice and faithful hand.

As the various effects of heat depend all on its power of feparating the particles of bodies, let us farther con-fider this firft effect, and attempt to eftimate its influence.

Water in the ftate of ice is foftened by a certain de-

gree of heat, melted, and reduced to fluidity by a great-
er, and by a ftill greater degree reduced to vapour, or
an elaftic fluid : fo that water in a ftate of vapour may
be faid to contain three fums of heat ;—that which con-
ftitutes ice of a certain denfity ; that which reduces
ice to the ftate of a liquid, rarefied to a certain degree ;
and, laftly, that which rarefies the liquid to an elaftic
fluid.

When we attempt to apply this theory to all natu-
ral bodies, they appear to be all capable of paffing
through thefe feveral ftates if expofed to a fufficient
heat. The only difference among them, in point of
this property, is, that fome may be reduced by a lefs
degree of heat while others require a greater. It is on-
ly for want of fufficient heat that we cannot reduce
rock-cryftal to a liquid or a vaporous ftate : nor is it
more difficult to conceive the poffibility of this event,
than to conceive an habitually elaftic fluid, fuch as air,
acquiring an extreme folidity, as happens to this very
fubftance in various combinations.

From thefe principles, it is eafy to explain the for-
mation of the elaftic fluids which are difengaged in
many of the operations of nature and art. It uniform-
ly happens, whenever a body receives and abforbs a
fufficient quantity of heat to caufe it to pafs into that
ftate of fluidity which conftitutes an aëriform fluid ;
and therefore all fluids that poffefs this property owe
it to heat. But it is alfo requifite, that the preffure of
furrounding bodies, efpecially the preffure of air, do
not oppofe this extreme dilatation ; or that the dilata-
tion be fo great as to overcome the refiftance which it
meets with in the gravity of the air. Hence a body,

whether

whether nearer to or more diftant from the ftate of elaftic fluidity, may be eafily reduced to this ftate by relieving it of the preffure of the atmofphere, as elaftic fluidity always takes place *in vacuo.* Hence evapotion is moft quick and copious on the tops of lofty mountains. And hence too it becomes neceffary to mention precifely, in a detail of experiments, with what degree of preffure any body was reduced to an elaftic fluid, or at leaft what preffure it can bear in that ftate : for it is alfo to be obferved, that all the bodies which can, with more or lefs eafe, be reduced to the ftate of vaporous or elaftic fluidity, do not maintain themfelves in that ftate with equal conftancy ; nay, fuch are the differences among them in this refpect, that they have been divided into *permanent and non-permanent.* The former remain long in the ftate of elaftic fluidity ; nor do they pafs from it, till by fome new combination they are deprived of the fubftantial heat by which they were maintained in that ftate. The latter, which may be denominated vapours, lofe their elaftic fluidity by degrees of preffure or cold which may be eafily eftimated, and readily communicate to furrounding bodies that portion of heat which conftitutes them aëriform fluids. Of this kind are water, alcohol or fpirit of wine, and æther ; thefe three fluids are reduced into vapours, and remain in that ftate when the barometer ftands at 28 inches,—water at 212° Fahrenheit, fpirit of wine at 180°, 30', and æther at 104°, &c.— It appears then, 1*ft,* That the ftate of elaftic fluidity is a mode of the exiftence of bodies occafioned by the combination of heat with their other principles: 2*dly,* That every elaftic fluid is a compound, confifting of a

2   bafe

afe of more or lefs folidity, and the matter of heat: 3*dly*, that the bafe of every elaftic fluid requires a certain egree of heat to reduce it to vapour or elaftic fluidity; nd that it is doubtlefs in confequence of their poffef-ng thefe properties, that elaftic fluids differ in gravity, lafticity, &c.

M. Lavoifier has explained this theory with great erfpicuity, in a memoir printed among the Memoirs f the Academy of Sciences for 1777.

Although we have diftinguifhed elaftic fluids into permanent and non-permanent, yet it is to be obferved, that this diftinction exifts not in nature. It is relative to the moderate heat and preffure of the atmofphere to which we are expofed in the climates in which we live, and over many parts of the globe; and if the cold and preffure were more confiderable, even the fluids which we at prefent confider as the moft permanent, would foon ceafe to be fo; and, on the contrary, æther and fpirit of wine would become permanent elaftic fluids at a certain height in the atmofphere, or in the warm temperature of the equatorial climates.

As the fubftance of heat, which contributes to the fonation of elaftic fluids, exifts in them in a combin- or *latent* ftate, and becomes not perceptible to our fenfes till thofe bodies lofe their fluidity by entering into combination with other fubftances; we have there-fore fought for an expreffion proper to denote heat in its ftate, and have adopted the word *caloric* for this purpofe; becaufe in this ftate heat may be actually confidered as having loft its original character, which recovers not till it be reftored to a ftate of liberty. Befides, by affixing to it this denomination, we avoid

the

the circumlocutions of the fubftance or matter of heat, or latent heat, which have been hitherto applied to it. Cooling, or the paffing of heat into the ftate of caloric, and ignition, or the paffing of caloric into the ftate of heat, depend both on the general law above laid down, that when bodies become more denfe, part of their heat is exhaled. Thus, whenever a gas or aëriform fluid is combined fo as to become a liquid or a folid, it lofes a great part of its fubftantial heat ; and to make it pafs into that ftate of denfity, it muft be expofed to the action of fome body, with which its bafe has a greater affinity than with heat. This is the general caufe of the fixation of elaftic fluids; and in this manner do they lofe that form by becoming fixed in liquid or folid bodies. We may likewife obferve that each of thefe fluids lofes more or lefs heat in proportion as it becomes more or lefs folid in the new combination, or in proportion as this compound body is capable of containing lefs or more fpecific heat. This obfervation explains why bodies burn with different degrees of rapidity; why they give during combuftion more or lefs flame or heat ; and why the refidues which they leave are more or lefs folid, &c. ; which phenomena fhall be more particularly mentioned in the following chapter.

Laftly, Since cold and preffure are the two means by which elaftic fluids are condenfed, we may perhaps be at length able, by employing intenfe degrees of both, to reduce all thefe from their gafeous ftate, and to obtain their bafes pure and feparate, by expelling the fubftantial heat which maintains them in fluidity. Thus we may come to know the bafes of vital air, azote, nitrogene, or mephitic gas, hydrogenous gas, &c. This

has

as been already performed on the fulphureous acid gas, which M. Monge has reduced to a liquid by means of an intenfe cold.

§ VI. *Of Heat as a Chemical Agent, and the feveral Ways in which it may be applied to Bodies.*

CHEMISTS employ heat, on account of the changes which it produces on bodies, both for decompofition and combination. Their firft object fhould be to meafure exactly the degrees of heat neceffary to produce all poffible alterations on any body expofed to it. Thefe degrees of heat are generally ranked under two claffes; the firft comprehending all degrees of heat below that of boiling water; the fecond, all above that temperature. The fcale of the thermometer marks out the former; our only means of determining the latter is the known fufibility of bodies.

Degrees of Heat below the point of boiling Water.

THE firft degree extends from 43° $15'$, to 54° $30'$, Fahrenheit's fcale. This temperature promotes putrefaction, vegetation, and gentle evaporation, &c. It is but feldom employed in chemical operations, as being too inconfiderable; in fome macerations made during winter, however, it is neceffary. It is likewife ufeful for the cryftallization of faline folutions, which after a proper evaporation are put into caves, or other places of this temperature.

The fecond of thefe degrees, extending from about 55° $45'$, to 77°, continues to promote putrefaction, excites a fpirituous fermentation in faccharine liquors, and

is

is favourable to evaporation and flow cryftallizatı
This is the ufual temperature of mild climates. Iı
employed for maceration, the folution of faline fubftı
ces, and fermentation, &c.

The third divifion or degree extends from about 8ı
15′, to 99° 30′. It excites the acid or acetous fermeı
tation in vegetables; and is fufficient for the exficc
tion of plants. It is ufed to effect fome folutions of falı
and to produce fermentation.

The fourth degree, which rifes to 133° 15′, is calle
the mean degree of hot water: this is the heat ufed i
the veffels called *balnea mariæ.* It deftroys the orgı
nization of animal fubftances, and volatilizes the ful
tler part of animal oils, more efpecially of the fpiriu
rector. It is employed in the diftillation of thofe vegı
table and animal fubftances, of which we wifh to ob
tain the phlegm and the odoriferous part.

The temperature of boiling water 212°, is ufed in de
coctions, and the extraction of effential oils.

Degrees of heat above the boiling point.

THE firft degree or divifion makes glafs red, burn
organized fubftances, and melts fulphur.

The fecond melts the fofter metals, tin, lead, bif
muth, and fuch glaffes as are moft eafily reduced to ı
ftate of fufion.

The third effects the fufion of moderately hard metalı
fuch as zink, regulus of antimony, filver, and gold.

The fourth burns porcelain, and melts the more re-
fractory metals, cobalt, iron, and copper, &c.

The laft and moft intenfe degree exifts in the focuı
of a burning-glafs. This temperature calcines, burns
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d vitrifies in an inftant, all bodies fufceptible of com-
uftion, calcination, or vitrification. A fimilar heat
may be excited by pouring from a blow-pipe a ftream
f vital air or oxigenous gas upon a piece of coal. M.
Monge is of opinion, that by prefenting to combuftible
bodies, when in a ftate of inflammation in a furnace, a
quantity of compreffed atmofpheric air, the fame effect
might be accomplifhed which is produced by vital air.
This procefs may be one day or other applied to very
important purpofes.

Though thefe degrees above the heat of boiling wa-
ter be determined by phenomena which are well
known to chemifts, yet they have not hitherto been
meafured with all the precifion that could be wifhed.
It is therefore an object of the utmoft importance to
obtain an inftrument capable of pointing out the exact
degrees of heat employed in thefe operations. Mr.
Wedgewood in England has conftructed a thermometer
for this purpofe : it confifts of fmall pieces of clay half
an inch in diameter. Thefe pieces, when contracted
by the heat, fall between two graduated rulers of cop-
per inclining towards each other upon a plate of the
fame metal; and thus fhow what contraction they have
fuffered, and of confequence to what degrees of heat
they have been expofed *(Jour. de Phyf. Ann.* 1787*.)*

The heat neceffary in chemical operations is produ-
ced by burning charcoal, or common mineral coal. We
ife on thefe occafions furnaces of different forms and
ames, according to the different purpofes for which
they

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* There is an accurate defcription of this ingenious contrivance, by
e inventor himfelf, in the Englifh Philofophical Tranfactions for
82.—H.

they are intended; fuch are the furnaces for digeſtion and fuſion, the reverberating furnace, the wind furnace, and the cupelling furnace. A ſingle furnace, properly made, is often ſufficient for the purpoſes of all theſe; and it is then called a *Polychreſt furnace.* The reader may conſult on this head the Chemical Dictionary of Macquer, who has contrived a moſt excellent and uſeful furnace; Baumé's Chemiſtry, Pott's Lithogeognoſia, and Abbé Rozier's *Journal de Phyſique,* in which there are deſcriptions of various furnaces conſtructed by different chemiſts. The flame of oil, or ſpirit of wine, is alſo employed ſometimes in lamp-furnaces adapted to the purpoſe.

The manner in which fire is applied to bodies in chemical proceſſes, likewiſe deſerves ſome explanation. If the combuſtible body be applied immediately to the ſubſtance on which you wiſh the fire to act, the operation is then ſaid to be managed with *naked fire.* But ſome intermediate body is often put between the fire and the ſubſtance expoſed to its action; hence the names *balneum mariæ,* ſand-bath, cinder-bath, dung-bath, &c.

The form of the veſſels made uſe of in ſubjecting bodies to the action of fire, and the various phenomena exhibited by bodies under the influence of heat, have cauſed a great variety of operations to be diſtinguiſhed by peculiar names. Such are roaſting, calçination, fuſion, reduction, vitrification, cupellation, cementation, ſtratification, detonation, decrepitation, fulmination, ſublimation, evaporation, diſtillation, rectification, concentration, digeſtion, infuſion, decoction, lixiviation. All theſe operations are performed by the action of fire, and enter into the practice of chemiſtry;

and

nd we shall therefore give a short explanation of each
f them.

Roasting is a preliminary operation, which prepares
mineral substances for undergoing a series of succeed-
ing ones, dividing their constituent particles, volatili-
zing some of their principles, and producing a certain
alteration on their nature. Mineral ores are exposed
to this process on purpose to separate the sulphur and
arsenic which they contain, and to diminish the cohe-
sion of their particles. Capsules of earth or iron, cru-
cibles, and roasting pots, are the vessels in which it is
usually performed; and it is generally exposed to the
access of the external air. Sometimes, however, the o-
peration is performed in close vessels; and two crucibles,
luted mouth to mouth, are commonly employed on such
occasions.

Calcination is, as it were, a more advanced stage of
the process of roasting. By this process minerals are de-
prived of their water and salts; it likewise reduces cal-
careous substances to the state of quick-lime, and metals
to metallic oxides. The same vessels are used in this
process as in the former.

In fusion, a body is caused to pass by fire from a fo-
lid to a fluid state. The chief subjects susceptible of
this operation are salts, sulphur, and metals. Crucibles
of baked clay of various kinds and figures, with metal-
ic cones and ingot moulds, are the instruments for this
peration. These last are employed to give the melted
matter a certain form; which they mould into bars, in-
ots, or buttons.

In reduction or revivification, the calces of me-
als are, by means of fire, with charcoal or oils, re-
stored

ftored to the metallic ftate which they loft by calcina-
tion.

Vitrification is the fufion of fuch fubftances as are
capable of affuming the brightnefs, tranfparency, and
hardnefs of glafs. Vitrifiable earths with alkalis, and
the oxides of metals, are the chief of the fubftances fub-
jected to it.

Cupellation is the purifying of perfect metals, by the
extraction of fuch imperfect metals as are intermixed
with them. This is performed by the addition of a cer-
tain quantity of lead to the mixture, and the expofing
of it to a due heat; which vitrifies the lead, and toge-
ther with it the imperfect metals of the original mix-
ture, leaving the perfect in a pure and feparate ftate.
This operation derives its name from the veffels ufed in
it. Thefe are a kind of flat crucibles, refembling the
fmall cups known under the name of *cupels*; and the
fubftance of which they are compofed, being the earth
of bones, is fufficiently porous to abforb and retain the
lead that is fcorified by the heat.

The name of *cement* is given to powdered fubftances,
with which other fubftances expofed to their action
are carefully covered over. Thus, iron is covered over
with powder of charcoal, that it may be converted into
fteel; and glafs with plafter or filex, to change it into
a kind of porcelain. The procefs by which this is ef-
fected is cementation, and requires the action fometimes
of a very ftrong fire.

Stratification is an operation nearly fimilar to the
preceding. It confifts in arranging feveral folid fub-
ftances, ufually in in horizontal layers, and intermixed
with certain pulverifed bodies, to alter their nature,
                                                    either

er in a crucible or in fome other fuitable veffel ca▴
le of bearing the action of fire. This has received
name of *ftratification,* becaufe the fubftances are dif-
ed in ftrata or layers, one rifing above another.
per and filver are treated in this manner with ful-
ir, in order to effect their combination. This pecu-
: arrangement of fubftances, named *ftratification,* is
en employed preparatory to fufion, calcination, vitri-
ition, &c.

Detonation is peculiar to nitre and the mixtures into
ich it enters. It is the explofion of fuch bodies when
ited in open or clofe veffels. Decrepitation differs
en detonation only as producing a fainter noife,
ich is merely a kind of crackling found; it is pecu-
r to certain falts; which from a ftate of folution are
ftallized fo rapidly, that the cryftals formed burft in-
minute pieces. This has been obferved chiefly of
mmon falt, or muriate of foda. Fulmination is a
more quick and lively detonation; fuch as takes place
fulminating gold, fulminating powder, and in the
mbuftion of inflammable gas and vital air, &c.   ·

Sublimation is the volatilizing of dry, folid, and oft-
cryftallized fubftances by means of fire. The vef-
t, ufed in fublimation are glazed earthen pots, earthen
icibles with glafs heads, and pots of earth or porce-
n, arranged one above another, and joined by the in-
tion of their necks one into another, which are known
the name of *aludels,* &c. Sulphur, arfenic, cinnabar,
ny mercurial preparations, fome vegetable fubftan-
, more efpecially camphire and flowers of benzoin,
the fubjects of fublimation.

Evaporation is the action of heat on liquids, to dimi-

nifh their fluidity and quantity, and to obtain the fixed
bodies diffolved them in a feparate ftate. Thus, we e-
vaporate the water of the fea and of falt fprings, in or-
der to obtain the falt which they contain. This opera-
tion is performed in capfules, jars, earthen or glafs eva-
poratories, and filver pans, according to the nature of
the liquid to be evaporated. The evaporating fubftance
is expofed to the contact of the air, in order that the wa-
ter, the body to be carried off by volatilization, may dif-
fufe itfelf through the atmofphere, and that the air by
its folvent power may promote the evaporation.

Diftillation is an operation nearly fimilar, but per-
formed in clofe veffels. It is ufed to feparate volatile
from fixed principles by means of fire. The diftillatory
veffels are alembics and retorts. The firft confift of a
lower veffel named a *cucurbite*, intended to contain the
body to be diftilled, and an upper part or capital exact-
ly fitted to it; the purpofe of which is to receive the
volatilized fubftance, and condenfe it by the coldnefs
of its temperature (which is maintained by the contact
of the external air, or of water furrounding it); when
water is ufed, the veffel containing it, into which the
upper part of the alembic is immerfed, is called a *cooler*,
or *refrigeratory*. From the lower part of the capital
there proceeds a kind of beak or fpout, through which
the vapours pafs into a pipe, where they are condenfed
into a liquid: from this pipe the liquid thus obtained is
conveyed into other veffels, which are commonly of a
fpheric form, and are named *receivers*. Thefe receiv-
ers are of various forms and names, matraffes, balloons
&c. A retort is a kind of glafs, ftone, or metal bottle,
of a conical form, with its extremity bent, fo as to make

n acute angle with its body; and on this account has t received the name *retort.* Diftillation has been ra- ther improperly diftinguifhed into three kinds, namely, diftillation afcending, *per afcenfum;* diftillation defcend- ing, *per defcenfum;* and lateral diftillation, *per latus.* This diftillation is warranted only by the exterior form of the veffels made ufe of. The volatilized matter has always a tendency to afcenfion: But diftillation per- formed in glafs or metal alembics has received the pe- culiar denomination of *afcending,* becaufe the capital is placed over the cucurbite, and the vapours are feen to afcend. The diftillation performed in retorts is called *lateral,* becaufe the beak or neck of that veffel comes out at the fide of the apparatus; but the cavity of the retort in which the vapours are condenfed is higher than its neck, and the diftilled fubftance paffes through that cavity, before reaching the neck. As to diftillation *def- cending,* it was an operation which fcarce ferved any pur- pofe, and is now no longer ufed; its produds were always in a very bad ftate, and great part of them was loft in the procefs. It was performed by fpreading a piece of cloth over the mouth of a glafs, placing upon it fome vegetable fubftance, and covering this with the fcale of a balance, or with a capfule of metal containing fome live coals. This mode of diftillation was formerly ufed in pharma- cy and perfumery, for obtaining the effential oils of fome odoriferous fubftances. The produd paffing through the cloth dropped into the glafs, which was al- ways half full of water, to cool the oil; but moft part of the effence was always loft on the cloth and the me- tal plate above. A more ufeful diftindtion is that which regards the manner in which the fubftances to be diftil-

led

led are warmed. This is performed either with
balneum mariæ, by dipping the cucurbite in boiling
ter, or with the vapour, the fand, or the cinder-bat
with naked fire. It is alfo effected by means of
flame of a lamp, and by that of fpirit of wine.

Rectification is a fecond procefs of diftillation,
object of which is to purify a liquid fubftance.
heat is employed to carry off the pureft and moft
tile part, leaving the more fixed matter, which del
it, in a feparate ftate; as is done, for inftance, witl
rit of wine, æther, &c.

Concentration is the direct contrary of rectifica
its object being to volatilize part of the water, and
improve the ftrength of the fluids concentrated.
matter to be concentrated therefore muft be of fuр
gravity to water. This operation is performed on
acids, particularly on the fulphuric and the pho
ric; it is alfo employed in folutions of alkalis and
tral falts.

Digeftion is the expofing of fubftances which we
to act gently on one another to a gentle and long
tinued heat. It is chiefly ufed to extract thofe pa
vegetable fubftances which are foluble in fpirit of
or other fluids. Chemifts formerly put great confic
in this operation. Though that confidence feems to
been juftly due, as it appears from many painful r
ches, that too active or too rapid a fire alters the n
of moft vegetable and animal fubftances; yet mo
chemifts do not depend on this procefs with the
enthufiafm as the alchemjfts of old. The patient in
try of thefe men was often employed for a ferr
years on one procefs of digeftion: for by fuch proc

they expected to perform wonders. Digeftion is now confined to dyeing ftuffs, elixirs, and liquors for the table; it is always fuccefsfully employed to extract the principles of vegetables and animal matters, without altering them. It is likewife ufeful in feveral operations in minerals.

Infufion is a well-known procefs : it confifts in pouring warm or boiling water on fubftances of which we wifh to extract the moft foluble parts, and of which the contexture is fo flight as to be eafily penetrable, fuch as thin bark, wood in fmall thin pieces, leaves, flowers, &c. It is of great ufe for feparating fubftances that are eafily foluble, and is often employed in chemical operations.

Decoction, or the continued ebullition of water with fubftances on which it acts, is ufed to feparate thofe parts of bodies which are not foluble by a more moderate degree of heat. It produces confiderable alterations on vegetable and animal matters ; often effecting an entire change of their properties. It coagulates the lymph, melts greafe and rofin, and hardens the fibrous parts of a vegetable or animal. When the chemift is well acquainted with its effects, he may employ it with confiderable advantage.

In the procefs of lixiviation, we diffolve, by means of warm water, the faline and foluble particles of cinders, the refidues of diftillation and combuftion, coals, and fuch natural earths as we wifh to analife. This operation very naturally derives its name from the *lixivial* falts which are obtained by means of it. The word *leffive* is at prefent ufed in France as fynonymous with *lixiviation*, and is even more frequently ufed. This operation, then, is merely a folution effected by means of

heat:

heat : it is likewife nearly fimilar to infufion ; th
difference is, that the latter is applied to vegetat
animal matters ; while lixiviation is only emplc
obtain fubftances poffeffing fome of the propei
minerals.

Thefe are all the operations in chemiftry ia
fire is called in to act a part. Formerly, inde
chemical operation was performed without the
this agent : and the fcience was on that account
Pyrotechny. But as methods of analifing bodie
been fince difcovered which are much lefs liabl
ror and more certain in their refults ; the agi
fire is now much lefs ufed in chemiftry than
ly. The action of folvents, or menftrua, en
in a cold ftate, or in the ordinary temperature
atmofphere, is often fufficient to accomplifh tl
furprifing changes on natural bodies, and
ground for the moft accurate inductions. This
has been applied to the examination of falts,
and vegetable matters, &c. with the happieft
Heat is no more than a fecondary mean, a kind
iliary that affords fome affiftance on fuch oc
As different degrees of heat are requifite in c
operations, it would be a happy circumft:
fome means were contrived, by which we migh
abled to apply always the fame precife degrees
when the fame effects were wanted. Chem
philofophers have long wifhed for a furnace
might afford regular and uniform degrees o
Hitherto, however, the manipulations of arti
given the only means that can in any degree fe
purpofe. But perhaps it is not impoffible to obt

Y

precifion which we defire, and of which the utility is
fo obvious. Dr Black is faid to have invented a kind
of furnace, by which he can command a regular and
uniform heat by means of a damping-plate with holes,
which may be opened or fhut at pleafure. We have
not received a fufficiently accurate defcription of it, to
enable us to conftruct any on the fame model. But we
hope that a difcovery fo beneficial to chemiftry will not
be long unknown in France *.

* For meafuring HEAT with the accuracy which is requifite for the
purpofes of fcience, the following means and inftruments have been em-
ployed.

1. Graduated glafs tubes, filled with different fubftances which are
rarefiable by heat, and named THERMOMETERS. Of thefe, the THER-
MOMETERS filled with mercury, have now almoft fuperfeded the ufe of
thermometers filled with fluids. The THERMOMETERS the moft com-
monly in ufe, are thofe of *Fahrenheit, Reaumur*, and *Celfius*. The *ther-
mometer of Fahrenheit* is that generally ufed in *Britain*. *Reaumur's ther-
mometer* is commonly employed by the French philofophers. A de-
gree of *Fahrenheit's thermometer* is equal only to ⅘ of a degree of *Reau-
mur's*; and to ⅘ of a degree of *Celfius' thermometer*. To reduce the de-
grees of *Reamur*, to the degrees of *Fahrenheit*, multiply by 9, and di-
vide by 4. To reduce the degrees of *Celfius* to thofe of *Fahrenheit*,
multiply alfo by 9, but divide by 5.

2. The well known pyrometer of Mufchenbroek.

3. Mr. *Leidenfroft* having obferved, that the hotter a metal is, fo
much the more flowly will drops of water evaporate from its furface ;
he applied this principle to the meafurement of the higher degrees of
heat. On iron heated to the degree of boiling water, a drop of water
evaporates in *one fecond :* On melted lead, in 6 or 7 *feconds :* On red-
hot iron in 30 *feconds*. At 520° Fahrenheit, the hot body evaporates
a drop of water in 89 feconds.

4. The pureft clay fhrinks in the fire, in proportion to the heat ap-
plied to it. And upon this principle, the ingenious *Mr Wedgewood* con-
ftructed one of the beft *pyrometers* with which we are acquainted. It confifts
of a graduated gauge ; the rule of which is divided into 240 equal parts,
each being $\frac{1}{10}$ of an inch ;—and of other pieces of the fame clay, baken
a red heat, and of given dimenfions, which are applied to the heat

to be meafured, and are then again applied to the graduated ga
which fhows how much they have fhrunk, and by confequence afl
a meafure of the heat to which they have been expofed.

5. The inftrument of *Meffrs. Lavoifier* and *De la Place*, for me
jng heat by the melting of ice, is perhaps more accurate than an
ther pyrometer. It confifts of three circular veffels, nearly infci
in each other ; and affording three feparate capacities, or recei
fpaces. The *interior* cavity, formed by an iron grating, upon fup
of the fame metal, and clofed on the upper part by a cover, is de
ed for the reception of the body fubjected to experiment. The 1
cavity contains the ice, the melting of which is to meafure the he
ven out by the body under experiment. The *exterior* cavity cot
ice intended to preclude any heat out of the atmofphere, from p
into the *middle* ice, which is to be melted by the heat of the *interio*
dy alone. The water produced by the melting of the middle :
weighed ; and its weight affords a meafure of the heat given out.

For the defcription of Dr. Black's furnace, fee *the Edinburgh
Difpenfatory*, 4th edition, pages 48, 49, 50, 51, with fig. 7, {
of Plate I.—H.

C H A

C H A P. VL.

Of Atmospheric Air.

COMMON air is an invisible, inodorous, insipid fluid possessed of gravity and elasticity, extremely susceptible of motion, and capable also of rarefaction and condensation, which encompasses our globe to a certain height, and composes the atmosphere. It likewise insinuates itself into, and occupies, the interstices or pores between the integrant parts of bodies. The atmosphere which encircles our globe is far from being pure air. As it receives all the vapours that arise from the surface of the earth, it may be considered as a kind of chaos, or heterogeneous mixture. We shall soon see, however, that its nature is at present pretty well known. Water, mineral exhalations, and elastic fluids disengaged from minerals and metals, are incessantly carried up into the atmosphere, and may be said to constitute its elements. The objects of attention in a natural history of the atmosphere are, its height, the precise degree of which is not yet accurately determined; the variations to which it is liable; its gravity; its different strata; the effects of its rarefaction and dilatation; winds, and meteors. But these come under that part of physics which is known by the name of *meteorology*, and form no part of the province in which we are engaged. Yet as air has a powerful influence on che-

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mical phenomena, and it is of confiderable importance
to know the nature and extent of that influence, we
fhall here examine both the phyfical and the chemical
properties of air.

§ I.   *Of the Phyſical Properties of Common Air.*

FLUIDITY, invifibility, infipidity, gravity, elafticity,
and negation of fmell, may be confidered as the phyfi-
cal properties of air.   Each of thefe merits a particular
examination.

Such is the rarity of this fluid, that it readily yields
to the flighteft impulfe, changing its fituation on the
fmalleft motion of bodies immerfed in it.   This kind of
fluidity depends on the degree of its aggregative force;
and as it is not confined to atmofpheric air, but is found
to characterife feveral other fluids, thefe are called
aëriform fluids, or *gafes*.   What conftitutes the pecu-
liar nature of aerial aggregation, is, incapacity to pafs
into a folid ftate; contrary to what moft liquid bodies
are fufceptible of.   But this, however, no more is to
be underftood, than that hitherto we have not been a-
ble to apply to it any degree of preffure or cold fuffici-
ent to accomplifh this effect.   This is the diftinguifhing
characteriftic of permanent gafes.   The fluidity of the
air expofes it to thofe frequent and rapid motions which
conftitute the winds.   It is not, however, capable of pe-
netrating into all bodies.   Tranfparent matters, through
which light readily makes its way, are fecure againft
the impulfe of air.   Water, folutions of falts, oils, and
fpirit of wine, pafs through many bodies whofe con-
texture is fuch as not to admit air.   Thofe liquid fub-

ftances

are endowed with the property of dilating fuch
, enlarging their pores, and diminifhing the
efs of their contexture; of which air is def-

, when confined in veffels, is abfolutely invifible,
be diftinguifhed from the glafs that contains it :
when entirely filled with this fubftance, phials
t to the eye a feeming vacuum.   It owes this
ty of invifibility to its tenuity and the ready paf-
hich it affords to the rays of light : thefe are re-
l,without being reflected by it. And it is therefore
ite of colour ; though fome natural philofopher*
perfuaded themfelves that they difcovered large
ns of it to be blue.

uralifts have uniformly confidered air as an infi-
dy.   Yet, in attending to what happens, when
rves of animals are expofed to the contact of this
as in the inftance of wounds, and on other fimi-
:afions, we cannot but obferve that it has a kind
igency ; of which we are not generally fenfible,
becaufe we are fo conftantly accuftomed to it.
ds, when uncovered and expofed to the air, are
d with an acute pain.   A new-born infant ex-
i by its cries the difagreeable fenfations which it
rom the firft contact of the external air.   This
ncy of the air is to be confidered as the reafon
rounds that are expofed to it, uncovered, remain
ig open.   Atmofpheric air, in the fame manner,
.es the growth of new bark on fuch vegetables as
been ftripped of their covering.   In order that
nay regain their bark, they muft be covered o-
th fome body which may exclude the air.

As

Air is perfectly inodorous. If the atmoſphere ſome. times affect our organs with a kind of fetid ſmell this is to be attributed to the extraneous bodies that are mixed with it ; as may be obſerved in miſts and vapours.

The gravity of air is one of the fineſt diſcoveries of natural philoſophy : the fact was never certainly known till about the middle of the laſt century ; though Ariſtotle indeed is ſaid to have known that a bladder was heavier when filled with air than when empty. The ancients had no diſtinct idea of the gravity of air, but aſcribed to a certain occult quality, which they called *abhorrence of a vacuum,* all thoſe phenomena which depend on the weight of this body. Certain workmen finding it impoſſible to raiſe water by a pump above the height of two and thirty feet, were induced to conſult the famous Galilæo on the occaſion. He was amazed at the phenomena. Death prevented him from diſcovering the reaſon of it ; but this was after-wards diſcovered by his diſciple Torricelli in the follow-ing manner. He reflected, that water could not riſe in a ſucking pump, without being impelled by ſome ex-terior cauſe, the preſſure of which forced it to follow the motion of the piſton. The influence of that cauſe muſt be limited, ſince it never raiſed the water above the height of two and thirty feet. Therefore, if it were to act upon a body of greater ſpecific gravity than water, it would raiſe that body only to a height proportioned to its gravity. He next took a glaſs tube ſix and thirty inches in length, and hermetically ſealed at one end : this he filled with mercury, holding the cloſe end down, and ſtopping the upper end with his
 finger,

finger, after he had poured in the mercury : then, turning the cloſe end up, he immerſed the other into a veſſel full of mercury ; and upon removing his finger, found that part of the mercury in the tube had fallen down into the veſſel, but that a conſiderable quantity ſtill remained ; which after various oſcillatory motions, at length ſettled at 28 inches. By comparing this with the height of 32 feet, to which water roſe in the pumps, he perceived that the difference of the elevations to which theſe two fluids roſe was in exact proportion to the difference between their ſpecific gravities; for the proportion of the ſpecific weight of mercury to that of water is as 14 to 1, and the water roſe 14 times as high as the mercury. It was not, however, till after long reflection, that he began to conjecture the weight of the air to be the cauſe why fluids were thus ſuſpended in a pump. Nor was the exiſtence of this weight certainly determined, till after the ingenious experiment which Paſchal directed to be made in France.

This celebrated philoſopher imagined, that if it were actually the weight of the air which cauſed water to riſe to the height of 32 feet in a pump, and mercury to the height of 28 inches in Torricelli's tube, theſe fluids would riſe to different elevations on the ſummit of a mountain and in a vale ; as in the former caſe the weight of the atmoſphere muſt be diminiſhed. In conſequence of this ſuggeſtion of Paſchal's, Perrier made the famous experiment which finally determined the opinions of philoſophers concerning this phenomenon, on the 19th September 1648, at the foot and on the ſummit of the mountain Puits de Dome, in Auvergne. The barometer, or Torricellian tube, being filled with

mercury, and fixed to a ſcale of 34 inches, divided into
inches and lines, the mercury roſe about four inches
higher at the foot of the mountain than on its ſummit,
which is 500 toiſes higher. From this it was determi-
ned that the mercury varied about an inch for every
hundred fathoms: and the barometer has ſince that time
been very ſuccefsfully applied to the meaſurement of
the height of mountains.

The weight of the air has an influence on many
phyſical and chemical phenomena. It compreſſes all
bodies, and reſiſts their dilatation ; it oppoſes the eva-
poration and volatilization of fluids: and to it the wa-
ters of the ſea owe their liquidity ; for they would
otherwiſe be reduced to vapour, as may be obſerved of
fluids placed in the vacuum produced by the air-pump.
Air, by its gravitation on our bodies, retains both the
ſolids and fluids in their proper places : and the blood
often burſts through the ſkin, or from the lungs, on
the tops of mountains, occaſioning hemorrhagies; be-
cauſe the gravity and preſſure of the air are there con-
ſiderably diminiſhed.

Laſtly, air poſſeſſes great elaſticity. However ſtrong-
ly compreſſed, it inſtantly returns to its former rarity
aſſoon as the compreſſing cauſe ceaſes to act upon it.
The truth of this aſſertion is proved by a great many
experiments. We ſhall here mention only the moſt
obvious and moſt concluſive of thoſe phyſical facts by
which it is evinced. Take a tube of glaſs, bent into a
form ſomewhat like the letter U, and cloſe at one end ;
fill it nearly up with air, and then pour in a quantity
of mercury to prevent the air from eſcaping : you may
thus compreſs the air ſo as to know what degree of
compreſſion

compreffion this elaftic fluid is fufceptible of, by com-
paring the diminution of its bulk with the height of the
column of mercury employed to comprefs it. A foot-
ball, which being filled with air rebounds from any
hard body, affords another proof of the elafticity of this
fubftance. The fountain by compreffed air, gives an
inftance of the fame fact: Air being compreffed into
the fuperior part of this veffel, is foon dilated by the
heat of the atmofphere, fo as to force the water out by
a tube to a confiderable height. Laftly, the wind-gun,
the effects of which are generally known, is another
inftrument for fhowing the elafticity of air, and the
compreffion of which it is fufceptible. It is computed,
that air may be compreffed into $\frac{1}{113}$th of its ordinary
bulk.

Heat, which rarefies it by counteracting any com-
preffive force to which it is expofed, fhows that it is no
lefs capable of enlarging its bulk by dilatation. If a
bladder full of air be expofed to the heat of a furnace,
the air will be dilated fo as to burft the bladder with a
violent explofion. This is likewife often the caufe of
the burfting of the veffels in chemical operations;
againft which, however, proper precautions are now
adopted. The diminution or total abftraction of the
weight of the atmofphere, which is effected by the air-
pump, affects a bladder filled with air in the fame man-
ner as a violent heat.

The reader will naturally conclude from this ac-
count of the gravity and elafticity of air, that many of
the variations which we obferve in the atmofphere and
on the barometer are owing to thefe properties. In
fact, the inferior fupport the fuperior ftrata of the at-

mofphere ; and the compreffion of a ftratum of air is always fmaller or greater in proportion as it occupies an higher or lower fituation. Heat alfo, which is conftantly varying, has the power of modifying this gravity and elafticity. Thefe are the reafons why air is found to be lighter, keener, and more agitated, &c. on the tops of mountains, than on plains and other lefs elevated fituations. To underftand thofe aftonifhing phenomena which the barometer offers to our attention, we muft ftudy the gravity and elafticity of the atmofphere, as well as the changes to which it is liable, from the influence of heat. M. de Luc and M. Sauffure, have for fome years paid much attention to this clafs of the phenomena of nature.

§ II.   *Of the Chemical Properties of Common Air.*

THE properties above defcribed are all that were anciently confidered by philofophers as belonging to air. Several chemifts, at the head of whom Van Helmont, Boyle, and Hales, deferve to be ranked, obferving that air, or at leaft a fluid with all the apparent properties of air, was obtained in the analyfis of many natural bodies, inferred, that this element fubfifted in thofe bodies in a combined and fixed ftate. Hence arofe the name *fixed air*, which was at firft given indifferently to all the elaftic fluids obtained in chemical operations. The above mentioned philofophers fuppofed thefe fubftances to be of the fame nature with atmofpheric air: But Dr Prieftley has difcovered a number of elaftic fluids, which, though apparently the fame with common air, yet differ from it in many refpects.

We

We muſt then have recourſe to other qualities, if we wiſh to diſtinguiſh atmoſpheric air from the other aëriform fluids, which like it are inviſible and elaſtic. Its chemical properties afford the only criterion on which we can eſtabliſh this diſtinction.

In examining the diſtinctive properties of air, we find two which are peculiar to it, and may very well ſerve to mark its character; one, its being favourable to combuſtion or inflammation; the other, its ſerving to maintain animal life in reſpiration. Let us carefully examine theſe two great phenomena.

It is exceedingly difficult to give a good definition f combuſtion. It is not one, but a number of phenomena which combuſtible bodies offer to our obſervation, then they are heated and expoſed to the action of the ir. The chief of them are heat, motion, flame, redneſs, nd the change of the nature of the ſubſtance that is urnt. There are many varieties among combuſtible bodies. Some of them burn briſkly, and afford a brilliant ame, ſuch as oils, wood, reſinous and bituminous ſubſtances, &c.: others burn away without producing a diſcernible flame; as for inſtance many of the metals, and charcoal which has been properly prepared: others again are conſumed by a ſlow motion, ſcarce obſervable, almoſt without ſeeming to be on fire, but always with a degree of heat;—ſuch is the combuſtion of ſome metallic matters. Combuſtion, however, takes place equally in all theſe inſtances; and the body which has been once burnt in any of theſe ways, is no longer ſuſceptible of inflammation. The reſidue is always heavier than the combuſtible body. This may be eaſily proved to be the caſe with fixed combuſtible bodies. But again, thoſe

of

of which the inflammable matter is of a volatile nature, burn with more rapidity than the former, and their fix-ed refidue wants much of the original weight. From this it may perhaps be thought, that thefe laft lofe much of their weight in burning : but it is only a feem-ing lofs they fuffer ; and there are no combuftible bodies of which the refidues are not weightier than before combuftion. For, what remains fixed on fuch occafions is not the only refidue of the combuftible body ; a con-fiderable part of volatile combuftible bodies is converted into elaftic fluids, which afcend and are diffufed through the atmofphere : and were we to fuppofe that thefe leave no other refidue but what appears after their com-buftion on the fpot, or in the veffel where they were burnt, we muft believe what is impoffible, that they afford no refidue. Æther and fpirit of wine burn away without leaving the fmalleft particle ; but the fubftance into which they are converted is volatilized and diffuf-ed through the atmofphere. When means are em-ployed to collect it, it is found to poffefs more gravity than the combuftible body from which it was produced. Thus, by burning fixteen ounces of highly rectified fpirit of wine under a chimney adapted to the worm-pipe of a ftill, M. Lavoifier obtained eighteen ounces of water as the product of this combuftion. Oils, refins, &c. prefent the fame phenomenon. Thus, the cinders of burnt wood are not the whole of the refidue which it affords, the reft afcends in the air : one part, not being thoroughly burnt, becomes foot ; and the other mixing with the atmofphere, is condenfed into water, or depo-fites in it fome other elaftic fluids. It is therefore an e-

ftablifhed truth in chemiftry, that all combuftible bo-
dies acquire additional weight by being burnt.

To underftand how this addition of weight is acquir-
ed, we muft attend to another of the phenomena of com-
buftion, which it will be neceffary to explain more at
large. Combuftion can never take place without the
help of air, and is always in proportion to the purity and
the quantity of that fluid. Ever fince the difcoveries of
Boyle and Hales, philofophers have been ftruck with
this fact, and have propofed a variety of hypothefes to
explain it. Boerhaave thought that air contributed to
combuftion by operating on the furfaces of combuftible
bodies, fo as to diffect them, if the expreffion may ba
allowed, into their component particles. This hypothefis
did not explain why the fame air could not always pro-
mote combuftion. M. Morveau fuppofed this laft fact to
depend on the extraordinary rarefaction of the air by
heat; in confequence of which, it acquired fuch elaftici-
ty as to prevent the combuftion of inflamed bodies by
forcible compreffion. But he offered this ingenious hy-
pothefis at a time when it was impoffible to diftinguifh
the true caufe of the phenomenon. M. Lavoifier, by a
feries of fine experiments on the calcination of metals
with determinate quantities of air, has proved, that, as
John Rey the phyfician had before obferved, fo much air
is abforbed during calcination, that the calcined metal
acquires precifely that quantity of weight which the air
lofes during this procefs; and that the portion of air ab-
forbed actually remains in the metallic calx, as the cal-
ces of mercury may be reduced merely by expelling that
fluid. Other facts led him ftill farther. He obferved, with
Prieftley, that the air which remains after the procefs of

K 2   calcination

calcination or combuftion, can no longer ferve to pro—
mote new proceffes of the fame kind ; that it extinguifh—
es flame, fuffocates animals, and, in a word, has acquir—
ed a different nature.   He likewife found that its dimi —
nution is exactly proportioned to the quantity abforbed
by the combuftible body.   On the other hand, air ex-
tracted from metallic calces has been found to be three
or four times purer than atmofpheric air.   It not only
promotes combuftion, but even renders it much more
rapid.   A given quantity of the former will ferve for
the inflammation and total combuftion of three or four
times that quantity of matter which may be confumed
by the help of the fame portion of the latter.   To this
fingular fluid obtained from the calces of mercury, Dr
Prieftley, who firft difcovered it, gave the name of *de-
phlogifticated air ;* becaufe he confidered it as atmof-
pheric air deprived of the phlogifton, which, according
to him, is diffufed through the whole atmofphere.   Its
phlogifton he believed to be retained by the mercurial
calces, which are gradually reduced as this elaftic fluid
is difengaged by heat.   But as that name may lead to a
falfe idea of its nature, we fhall give it the name of *vi-
tal air ;* for it alone is the great agent in refpiration, as
well as combuftion ; and to ufe the expreffion of M. La-
voifier, it has four times as much of the genuine nature
of air as common air has.

From thus obferving, that air is abfolutely neceffary to
combuftion, and that part of the air neceffary to the cal-
cination of metals remains in the calces, M. Lavoifier
was at firft led to think, that combuftion confifted in the
abforption of pure air by the combuftible body.   Ab-
ftracting the water and vapours contained in atmofphe-
                                                    ric

air, he conſidered the ſubſtance that remained as a compound of two very different elaſtic fluids. One, of theſe, which is the only genuine air, and which promotes combuſtion by precipitating itſelf into the combuſtible body, and uniting with it, is vital air. It generally compoſes a fourth part of the atmoſphere, and ſometimes even a third part, when it is in its pureſt ſtate. The other fluid is deleterious to animals, and extinguiſhes flame ; and it conſtitutes three-fourths or two-thirds of the atmoſphere : it was at firſt named mephitic air. When a combuſtible body is expoſed to the air and kindled, a portion of the vital air in the atmoſphere becomes fixed in that body, and its combuſtion continues till it abſorb all the vital air immediately around it. The reſidue of the air, after it has loſt this pure vital part, can no longer contribute to combuſtion. It regains this power on being again qualified with a due quantity of pure air extracted from nitre or a metallic calx. This elegant theory propoſed by M. Lavoiſier in the years 1776 and 1777, appeared to explain all the phenomena of combuſtion. It accounted for the additional weight acquired by metallic calces, and the extinction of flame by air that had been already employed in combuſtion. But M. Lavoiſier, after continuing his experiments upon the ſubject, has thought proper to modify and enlarge it by new obſervations. The bright flame which is obſerved on immerſing a burning body in vital air, or on pouring this fluid on the ſurface of a flaming ſubſtance (which may be done by means of an ingenious machine of his invention) made him deſirous of knowing whence it proceeded, and whether, according to the theory of Stahl, it were owing to the diſengagement of phlogiſ-

ton. He inquired into this with the more attention becaufe the celebrated Macquer had ftill perfifted, notwithftanding *his* difcoveries, in maintaining Stahl's theory, but had laboured to reconcile *his* theory with that of the father of philofophical chemiftry. Macquer was of opinion, that pure air became fixed in combuftible bodies in confequence of their phlogifton being difengaged ; and that pure air and phlogifton were reciprocally precipitated ; the one from the atmofphere into the combuftible body, the other from that body into the atmofphere : in every procefs of combuftion pure air extricated phlogiftion into a ftate of liberty, and affumed its place ; and in the reduction of metals, phlogifton difengaged pure air and occupied the room which it had formerly poffeffed. M. Lavoifier obferving that the bright fparkling flame before mentioned, which affords the ftrongeft indication of the prefence of light or the matter of fire in a ftate of activity, feems rather to furround the exterior part of the body in combuftion, than to proceed as if it were difengaged from it ;—has been led to think that light and heat are feparated from vital air, in proportion as it is abforbed by the body in combuftion. His prefent opinion is, that vital air, like all other aëriform fluids, is a compound, confifting of a certain principle fufceptible of folidity, and of fire or the matter of heat ; that to its poffeffing the latter it owes its ftate of elaftic fluidity ; and that, being decompofed in combuftion, its fixed, folid principle, by entering into. combination with the combuftible body, increafes its weight and changes its nature,—while the matter of fire that it contains is difengaged under the form of light and heat. Thus, the modern

modern doctrine has beftowed on vital air what Stahl at-
tributed to phlogifton. If combuftion confift in the dif-
engagement of fire, it is the air, not the combuftible bo-
dy, which burns. As to the principle which, in com-
bination with the matter of fire, conftitutes pure or vi-
tal air, though M. Lavoifier have not fully explained
its nature, yet as it is often known to form acids by en-
tering into combination with combuftible fubftances, he
has conferred on it the name of *oxygene* *. With this
bafe, the fulphuric, arfenic, and phofphoric acids,
&c. are produced in the combuftion of fulphur, arfe-
nic, and phofphorus, &c. In all thefe bodies it is ftill
the fame. It is to be obferved, that according to this
new theory, the vital air which is obtained from me-
tallic calces did not exift in thefe calces under that form.
It becomes fuch, in confequence of the combination
that takes place between the heat and light communi-
cated through the veffels in which the calces are con-
tained during this procefs, and the *oxygene* by which
they are conftituted calces.

Such is the prefent ftate of chemical doctrine concer-
ning the nature of atmofpheric air, and its influence on
combuftion. The theory of which we have given an
account, is daily gaining new ftrength. The objections
urged againft it have but little weight : they even fhow,
that if its oppofers were better acquainted with it, they
would ceafe to raife their voice againft it, and that when

K 4   it

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* M. Lavoifier gave it at firft the name of *oxigyne;* but finding it
neceffary to apply an analogous name to fome other fubftances, before
known by improper denominations, we have changed the *gyne* into *gene,*
as more expreffive of its Greek derivation.—F.

it shall become generally known, it will be unanimously received by the learned.

Respiration is a phenomenon nearly resembling combustion. Common air is decomposed in the one as well as in the other; that it may contribute to either, it must contain a certain quantity of vital air. When it is deprived of all its vital air, the mephitic residue is fatal to animal life. Respiration is in fact but a slower combustion, in which part of the heat of vital air enters the blood as it passes through the lungs, and is by it conveyed through the whole body. In this manner animal bodies receive their supplies of heat, which are absolutely necessary, as they are constantly giving out the heat which they contain, to the atmosphere and other surrounding bodies. To maintain the heat of the blood is, therefore, one of the chief purposes of respiration; and this beautiful theory explains why the blood of those animals that respire either no air or but very little, is always cold.

Messrs. Lavoisier and De la Place have discovered another service which the air performs in the act of respiration. It absorbs a certain principle that exhales from the blood, and appears to be of the same nature with coal. That substance being reduced into vapour enters into combination with the oxigenous part of vital air, and forms the carbonic acid which is discharged from the lungs by expiration. This fact,—the formation of the carbonic acid in the atmospheric air respired by animals, at the same time when the *mephitic* air is separated,—explains why such dangerous effects ensue from the shutting up of a number of persons together in close places; such as happens in thea-

tres, hofpitals, prifons, and the hold of a fhip, &c. Af-
ter this, we can no longer be furprifed at the noxious
effects of air altered by refpiration, by which perfons of
delicate conftitutions and great fenfibility of nerves are
particularly liable to be affected.

The atmofphere which encompaffes our globe ap-
pears, therefore, to' be fuffering continual alterations
from the two great phenomena of combuftion and re-
fpiration. That fluid would be very inadequate to
thefe two great purpofes, were there not other means
provided for renovating the atmofphere, and maintain-
ing it with conftant fupplies of vital air. In the fol-
lowing chapter, and in the third part, we fhall fee that
the organs of vegetables are defigned by nature to ex-
tract this vital air from water, as well as to pour it
into the atmofphere, when ftruck by the rays of the
fun.

§ III. *Of the diftinguifhing Properties of that Mephitic
Air, or Gas Azote, (or Nitrogene*,) which enters into
the Compofition of Atmofpheric Air.*

FROM the preceding account of atmofpheric air, it
appears to be a compound body, confifting of two gafes
or elaftic fluids; one of which maintains combuftion or
refpiration, but the other is entirely unfit for ei-
ther of thefe purpofes. The firft, which is named
vital air, exifts in the proportion of 0,27 or 0,28 ;
while the latter amounts to 0,73 or 0,72. We have
afferted the firft to be a compound of the caloric and
the

* I think *nitrogene* adopted by M. Chaptal, a more correctly ana-
logical name for this gas than *azote*; unlefs farther difcoveries fhould
induce us to adopt rather the term *alkaligene*, as expreffive of a more
general property belonging to it.—H.

the oxigenous principles ; the ſecond, like all othe
gaſeous bodies, is alſo a compound of the caloric prir
ciple with a baſe fuſceptible of ſolidity. To this ela
ſtic fluid, which conſtitutes more than two thirds c
the atmoſphere, M. Lavoiſier at firſt gave the name c
mofette ; becauſe it extinguiſhes combuſtion, and de
ſtroys animals. But ſince all gaſſes, except vital an
atmoſpheric air, are equally noxious, and are therefor
all equally intitled to the name of *mofettes* or *mephite*
which has been always applied to elaſtic fluids unfit fo
reſpiration ;—we have adopted the words *gas azote* a
the peculiar denomination of *this* aëriform fluid : an
we may of conſequence apply the ſubſtantive *azote*
or the term azotic principle, to the baſe of this gas
which, like the oxigenous principle, the baſe of vita
air, becomes fixed by entering into combination witl
a number of ſubſtances. In order to give ſome ide
of the nature of this gas azote, we ſhall mention a
few of its properties. It is ſomewhat lighter thar
common air, and therefore occupies the upper part o
rooms in which the air hath been altered by combuſ
tion or reſpiration. Though ſo noxious to animals, ii
the ſtate of elaſtic fluidity, yet the azotic principle
its baſe, is one of the component principles of ani
mal bodies ; from which it is extracted in great abun
dance. It is likewiſe one of the conſtituent parts o
volatile alkali, or ammoniac, and of the nitric acid
it appears to be abſorbed by vegetables, and perhap
alſo by animals. It is highly probable, that the ſame
principle enters into the compoſition of all alkaline
bodies, and may be conſidered as a genuine *alkaligi-*
nous principle, in oppoſition to the baſe of vital air
te

to which we have given the name of the *oxiginous* principle. Thus we are led to confider the atmof-phere as a vaft refervoir of *acidifying and alkalify-ing* principles, though it be itfelf neither acid nor al-kaline.

Here we can only mention thefe properties ; in the fucceeding part of the work they fhall be more particu-larly explained. Here we have only endeavoured to point out the difference between the two fluids of which our atmofphere confifts, and to fix the reader's attention on the nature of each as diftinct from the other,

C H A P.

C H A P. VII.

Of Water.

WATER was long thought to perform an important part in almoft all the phenomena of nature, and to be capable of affuming a vaft variety of forms, and entering into many combinations, without fuffering any alteration of nature, or becoming unable to refume its original ftate. But the late refearches of Meffrs Lavoifier, Meunier, de la Place, and Monge, have difcovered that water, like air, is compounded of more fimple. principles which may be obtained feparate. The period of this important difcovery conftitutes a glorious æra in the hiftory of chemiftry. We fhall afterwards fee by what means thefe philofophers accomplifhed the analyfis of water. Let us firft confider the phyfical properties of this body.

§ I. Of the Phyfical Properties of Water.

PHILOSOPHERS define water to be an infipid, ponderous, and tranfparent fluid, without colour or elafticity, extremely fufceptible of motion, and capable of paffing through the various ftates of aggregation, from the folidity of ice to the tenuity of vapour or elaftic fluidity.

It is found in almoft all natural bodies ; but nature has united it with many fubftances with which art has

not

not yet learned to make it enter into combination. It is obtained from wood, and from the moft folid bones ; it is known to exift in the hardeft and moft denfe calcareous ftones ; it conftitutes the moft confiderable part of animal and vegetable fluids, and even enters into the compofition of the folid parts of fuch bodies. Thefe are the facts which gained it a place among the number of the elements.

The natural philofopher views it as exifting in maffes over the globe, filling up its cavities, or furrowing its furface. Its hiftory comprehends that of the eternal ice which covers the fummits of fome lofty mountains and the polar feas, of lakes, rivers, rivulets, fprings, clouds, rain, hail, and fnow. It is diftinguifhed into terreftrial and atmofpheric water. It attracts the curious inquiry of the philofopher, in its paffing fucceffively from the furface of the earth into the atmofphere, and from the atmofphere upon the rifing heads of hills ; and again, in its gathering into ftreams, producing fprings, fountains, and rivers ; and in the laft form, holding its headlong courfe to its great refervoir the fea. Obferving the phenomena of this immenfe mafs of water, we behold it agitated with the moft tremendous motions ; we fee its fluctuations and currents fometimes raifing awful liquid mountains ; we fee it fometimes encroaching on the limits of the earth, and fometimes retiring within its ancient boundaries. Here new iflands fpring up from its depths ; there the foundations of ifles of ancient name are fapped, and they fwallowed up in its bowels. If we trace its action in fubterraneous cavities, we there find it engaged in humbler labours, producing falts and cryftals, and depofiting them

in

in the clefts of the rocks.   All thefe objeds mu
under our attention in purfuing the natural hi
water.   But we muft firft examine its phyfical a
mical properties.

The moft remarkable of thefe is its being ful
of various forms, and becoming by turns a fol
quid, or a vaporous body.   Let us confider it un
of thefe three modifications.

I.   *Of Water in the State of Ice.*

Ice feems to be the natural ftate of water;
chemiftry at leaft, we confider that, as the natu
of any body, in which its aggregative force is ft
But as it appears much more frequently in a liqu
liquidity is ftill confidered as the natural ftate o

Several phenomena highly worthy of obfervai
cur in the formation of ice.

1. The change of a liquid into a folid body
takes place on the freezing of water, occafions
of fome degrees.   In a thermometer immerfed int
ing water, the mercury rifes fome degrees abo'
while in another, in the open atmofphere of th
temperature, it either remains fixed at that]
finks below it.   It appears, therefore, that par
heat which is fixed in water in a liquid ftate, is c
ged and efcapes into the atmofphere when it af
folid form; and the fpecific heat of ice is adui
than that of water.   A fimilar difengagement
is obferved in the cryftallization of falts.

2. The external air promotes the formation
Water in a clofe veffel freezes but very flowly;
pofe it to the open air, even in the fame tempi

ᵈ ice will almoſt inſtantly appear.   A ſimilar pheno-
enon is obſerved in the cryſtallization of ſalts : many
line ſolutions, which in cloſe veſſels are maintained in
is ſtate, will almoſt in an inſtant diſplay cryſtals, if
ᵘ open the mouth of the veſſels and expoſe them to
e contaĉt of the atmoſphere.

3. Gentle motion is favourable to the produĉtion of
ᵗ.   The ſame thing is obſervable of ſaline cryſtalliza-
ᵗns.   By ſhaking ſome ſolutions, which otherwiſe
ᵒuld not produce cryſtals, we ſometimes ſee theſe ap-
ᵗar while the ſhaking is continued.   I have often ob-
rved this in ſolutions of calcareous nitrate and muriate.
heſe analogies between the formation of ice and that
ˈ ſaline cryſtals prove, that the former is aĉtually a
ᵉcies of cryſtallization.

4. The bulk of a piece of ice appears to be greater
ᵗan that of the water of which it is formed ; bottles
ᵃd other glaſs veſſels are burſt in conſequence of the
eezing of liquids with which they are filled. But this
ieĉt is to be aſcribed not to the water, but to the air
hich is diſengaged from it during its congelation. .

When ice is formed, it is diſtinguiſhed by the follow-
ᵍ properties.

1. It has been obſerved by M. Mairan, that when
ᵐed by a ſlow congellation, its cryſtals are in the
ᵐ of needles croſſing each other at angles of—from
ᵒ to 120°.   Sometimes its cryſtallization takes a re-
ᵘar and determinate form.   M. Pelletier, a diſciple
M. D'Arcet's, and member of the college of pharma-
ᵃ obſerved in a piece of fiſtulous ice, cryſtals in the
ᵐ of flat quadrangular priſms, terminating in two
ᵉdral ſummits, but with great varieti   ᵗ o-

ther hand, when ice is ſuddenly formed, and in larg ◄
maſſes, it becomes one irregular ſolid, exactly like that
produced when ſolutioɩ s of ſalts are preſſed cloſe toge-
ther, and ſuddenly cooled *.

2. Its ſolidity is ſo great, that it may be reduced to
powder, and carried about by the wind. In very cold
climates, ice becomes ſo hard that it may be hewn into
pieces like ſtone, and uſed in building. Nay we are
even confidently told that maſſes of ice have been hol-
lowed into cannons, and charged and diſcharged ſeveral
times before melting.

3. Its elaſticity is very great, much greater than that
of water in fluid ſtate. Throw a piece of ice on a ſolid
plane, it rebounds from it like any other hard body.

4. It has a keen, ſharp taſte, nearly approaching to
cauſticity. Every perſon knows what kind of ſenſation
ice gives when applied to the ſkin. Phyſicians employ
it in external applications as a tonic or diſcuſſive, &c.

2. Its gravity is leſs than that of the fluid on which
it ſwims; which ſeems to be occaſioned by its contain-
ing a greater quantity of air in proportion to its bulk.
The ſame phenomenon takes place on moſt of thoſe bo-
dies that admit of concentration by cold, and fuſion
by heat, ſuch as butter, fat, wax, &c. and ſtill ariſes

from

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* M. Sage informs us, that a piece of ice containing within it un-
frozen water; if broken ſo as to ſuffer the water to run out; exhibit
in its cavity beautiful, tetrahædral priſms, terminating in four-ſided
pyramids.

M. Macquart relates, that when it ſnows at Moſcow, in a humid
ſtate of the atmoſphere, the air is obſerved to be loaded with cryſtalli-
zations, regularly flattened, and thin as a leaf of paper. Theſe cry-
ſtallizations conſiſt of fibres diverging into ſix different rays from a
common centre. H.

I

n the ſame cauſe; for every ſubſtance is by itſelf
re denſe and weighty in its ſolid than in a fluid ſtate.
. Its tranſparency, at leaſt in irregular maſſes, is ob-
ed by air bubbles. You may be convinced of this
examining a piece of ice attentively; and if the ca-
es be opened under water, the air which they con-
will be ſeen to iſſue in bubbles from its ſurface.

. It melts at ſome degrees above 32°; the liquefac-
proceeding gradually from the ſurface to the cen-

. Paſſing from a ſolid to a liquid ſtatë, it produces
l in the ſurrounding atmoſphere. Modern chemiſts
ık that it abſorbs heat when it melts: and that the
ntity of the caloric principle which becomes fixed
t on that occaſion, is equal to the quantity of heat
ngaged when it paſſes from fluidity into the ſtate of
. The ſame phenomenon is common to all fluid bo-
that can be condenſed into ſolids, and again reduced
luidity by the variation of their temperature.

II. *Of Water in a Fluid State.*

THE properties of water in a fluid ſtate àre very dif-
ent from thoſe of ice.
1. Its taſte is much fainter, for it is generally confi-
ed as inſipid. And yet people that drink much of it,
diſtinguiſh differences in its taſte at different times,
.; which ſhows that it is not abſolutely inſipid.
4. Its elaſticity is leſs than that of ice. Some experi-
nts of the Academy *del Cimento*, have even cauſed
property to be entirely denied to it. But the Ab-
Mongez has proved the elaſticity of water by a ſeries
ngenious reſearches; and has even

experiments of the Academy admit of an inference di-
rectly oppoſite to that which has been deduced from
them.   For the ſpheres of metal, which had been filled
with water for thoſe experiments, continued to exſude
liquid drops after being taken out of the preſs ; which
could not have happened if the water had ſuffered no
compreſſion.

3. In the ſtate of a liquid aggregate, water is more un-
der the influence of the affinity of compoſition.   From
this circumſtance it has obtained the name of the great
ſolvent of nature.   It does indeed enter into union with
many bodies, and even contributes highly to the mu-
tual combination of bodies.

4. It ſeems incapable of combination with light,
which paſſes through it without producing or ſuffering
any alteration.   Light is known to change its courſe in
paſſing through water, ſo as to aſſume a more perpendi-
cular direction.

5. Heat dilates it to a gaſeous ſtate.   Its paſſing
from a liquid ſtate to that of aëriform fluidity, conſti-
tutes ebullition.   The cauſe of this phenomenon is,
that, part of the maſs of water under examination
having aſſumed the form of an elaſtic fluid, the heat
no longer ſuffers it to remain in union with that which
is ſtill liquid : each bubble riſes from the bottom of the
veſſel, and aſcends into the atmoſphere, in obedience to
the action of heat.   I have explained the cauſe of ebul-
lition at large in my *Memoires de Chimie*, publiſhed in
1784, page 334.

The weight of the air has a remarkable influence on
the ebullition of water.   It oppoſes its dilatation and
evaporation : And in proportion as the gravity of th

air is lefs or more, the refiftance which it oppofes to the
volatilization of water muft be weaker or more power-
ful. Thus, Fahrenheit obferved, that the temperature
of water in a ftate of ebullition is not always the fame.
In order then, to know with greater certainty the pre-
cife degree of heat at which water boils, we muft con-
fult the barometer as well as the thermometer, and we
fhall find the requifite heat always proportioned to the
weight of the air.

The influence of the weight of the air on the rare-
faction and ebullition of water becomes more remark-
able when we make our obfervations at various heights
in the atmofphere. Thus, *cæteris paribus*, water boils
eafier on the fummit of a mountain than in a valley or
on a plain; the heat requifite to produce ebullition be-
ing lefs in the former fituation than in either of the two
latter. All fluids are eafily rarefied at very elevated
heights; for this reafon, liquids that are highly vola-
tile, fuch as fpirit of wine, æther, and alkaline or am-
moniac gas, lofe much of their ftrength on the tops of
mountains; a fact which has been generally obferved
by natural philofophers, and fully determined by an ob-
fervation made by M. de Lamanon, at the height of
more than 1800 toifes above the level of the fea.
Abftract the weight of the atmofphere with the pneu-
matic engine, and you may heat water to ebullition,
and reduce it to a vapour, without raifing it to the tem-
perature of 122°.

Laftly, A third circumftance, befide the heat and
the gravity of the atmofphere, which affects the ebulli-
tion of water, is the drynefs or humidity of the atmo-
fphere; but as the influence of this circumftance is

tirely chemical, we fhall referve the confideration of it
to the next fection.

6. Boil water in a clofe veffel, and with a fuitable
apparatus for collecting the vapours; let thefe be con-
denfed by cold, and conducted into a receiver; what
is thus obtained is diftilled water. By this means wa-
ter is obtained pure, and feparated by thofe earthy and
faline matters which almoft always alter it, but are now
left in the bottom of the veffel. Chemifts, who always
need pure water for their experiments, provide them-
felves with it in this way. They pour river or fountain
water into a cucurbite of copper tinned over within:
this they cover with a capital inferted into a refrigera-
tory filled with very cold water, for the purpofe of con-
denfing the vapours; which are thus caufed to pafs in
drops into glafs-veffels prepared for their reception.
But in order to obtain diftilled water in the greateft pu-
rity, an alembic peculiarly adapted for this purpofe muft
be employed. To abridge the procefs of diftillation,
this veffel fhould be prepared on particular principles;
the cucurbite fhould be broad and flat, and the capital
of the fame form. Water thus diftilled is perfectly pure.
Chemifts formerly made ufe of fnow or rain water; but
thefe are now known to contain folutions of fome ex-
traneous fubftances.

Diftilled water has an infipid tafte, and when drunk
oppreffes the ftomach with a kind of weight; but after
being expofed to the open air, and brifkly fhaken, it
recovers its tafte, and may be drunk with fafety. Di-
ftillation does not alter water, it only deprives it of the
air which is always united with it in its ordinary ftate,
and communicates to it that lively frefh tafte which

<div align="right">renders</div>

renders it potable. Boerhaave diftilled a quantity of water 500 times fucceffively, without being able to difcover any alteration upon it. Some philofophers have at different periods afferted, that water is changed into earth; becaufe, at each new diftillation, it leaves a certain quantity of an earthy refidue in the bottom of the veffel. M. Lavoifier has made a feries of the moft accurate experiments, with a view to determine this. By weighing the glafs veffels employed in the procefs of diftillation, and doing the fame with the water diftilled and its refidue, he has difcovered that this earth is nothing but a part of the matter of the veffels ground down by the action of the water.

III. *Of Water as an Elaftic Fluid.*

WHEN water is reduced by the action of fire into the ftate of vapour or elaftic fluidity, it acquires new properties which diftinguifh it from what it was under the two former modifications.

1. If the air into which it is received be above the temperature of 65°, 45′, and not overcharged with humidity, it becomes perfectly invifible.

2. If the temperature of the atmofphere be below 54°, 30′, and, if it be already loaded with moifture, the watery vapour forms a white or grey cloud, which is very plainly diftinguifhable: The reafon of this is, that it is not diffolved in the humid air, as will be afterwards fhown; but a true precipitation actually takes place.

3. Its dilatation is fo confiderable, that, as M. Watt affures us from the moft accurate coi

pies, in this form, 800 times the space which it fills
when liquid.

4. Such is its elasticity, that when compressed, it
produces dreadful explosions; and is happily employed
in mechanics to move enormous masses. Its utility in
that valuable machine the steam-engine is well known
both to philosophers and artisans.

5. Agreeably to one of the most uniform laws of the
affinity of composition, it has a greater tendency to
combination in this state, in which its aggregative
force is weakest, than in the two former. Chemists
have frequently occasion to observe with what rapi-
dity water in the state of vapour dissolves salts, soft-
ens mucous substances, corrodes and calcines me-
tals, &c.

6. It is entirely dissolved in air; when precipitated
from the atmosphere, it constitutes dew. This solution
obeys the same laws with saline solutions; as has been
shown by M. Le Roy of Montpelier, in an excellent
memoir on the elevation and suspension of water in the
atmosphere, *(Melanges de Physique et de Medicine, Pa-
ris, 1771.)*

7. One of the most remarkable phenomena of water
in a vaporous state, is its power of quickening the com-
bustion of oil; as in the experiment of the æolipile ap-
plied to the enameller's lamp, in common fires of mi-
neral coal or charcoal, and in the burning of grease;
instead of extinguishing, water rather increases the
strength and fury of the flame in all these instances.
Thefe phenomena led Boerhaave to think that flame
was in a great measure composed of water. We shall
see how much this ingenious conjecture of Boer-
haave's

haave's is confirmed, or at leaft juftified by the modern difcoveries concerning water, when we come to fhow that this fluid, in a vaporous ftate, increafes the violence of flame, in confequence of being itfelf decompofed by the bodies in combuftion.

8. Water in vapour, and diffolvedin the air, is con-denfed, and part of it precipitated, when expofed to a temperature a few degrees above the freezing point; it then refumes its liquidity; and in this manner is dew produced. Sometimes, when expofed to a fudden cold feveral degrees below the freezing point, it is con-gealed into icicles, and feems to fuffer a kind of cry-ftallization: hence thofe hoar, icy incruftations that are formed in winter on the windows of apartments ex-pofed to the north: hence too thofe fmall icy flakes in-to which the aqueous vapours iffuing from the lungs are formed in Siberia and other countries expofed to an ex-treme cold.

§ II. *Of the Chemical Properties of Water.*

No other natural body is fufceptible of more combi-nations than water; and it has, on this account, long held the name of the *great folvent of nature.* The wa-ters of the fea, of lakes, of rivers, fprings, and foun-tains, are far from being pure, and are impregnated with almoft every other fubftance, efpecially with fa-line matters.

It combines with air in two ways: 1. It abforbs this elaftic fluid and retains it without paffing from its li-quid ftate. It even appears that water owes its pleafant frefh tafte to the air thus combined with it. The pneu-

matic engine proves the reality of this combination;
when the air above the water is exhaufted, that which
is mixed with it, is gradually difengaged in the form of
bubbles. The air contained in water may be obtained
by diftilling the water in a pneumato-chemical ap-
paratus. When water is boiled, the firft bubbles
that arife, confift of air, and the water, after lofing
them, has no longer the fame lightnefs or relifh. It
recovers thefe properties by being expofed for fome
time to the open atmofphere, or by being brifkly fha-
ken. 2. Air, with a certain degree of heat, diffolves
water, and renders it elaftic and invifible like itfelf.
The greater its heat, the greater alfo is its power of
maintaining water in a ftate of folution. Le Roy of
Montpelier has examined with minute attention the
ftate of water in the atmofphere. His ingenious expe-
riments fhow, that the drieft hot air, if inclofed in a
flafk, and cooled to a certain temperature, affords a
precipitate of water ; that more or lefs aqueous va-
pour is neceffary to faturate the fame quantity of air
according to its heat ; and that this water is precipi-
tated from the atmofphere through the night, and
forms a particular kind of dew. He has even been led
to think, from thefe facts, that the weight of the at-
mofphere depends upon the quantity it contains of
this water, which is always in proportion to its tem-
perature.

Though it be not confiftent with the method which
we propofe to follow, to enter upon the examination
of faline matters in this place ; yet we muft obferve,
that water, as it poffeffes in an high degree the pro-
perty of diffolving them, always contains a certain

quantity of fome faline fubftance. Calcareous falts are moft frequently mixed with water, and communicate fome difagreeable, and fometimes even noxious, qualities to well and river waters. Thefe are fometimes alfo found to contain a portion of the carbonic acid, of clay, of iron, and of the extracts of vegetables altered by putrefaction. All fuch waters are unwholefome; thofe vitiated with the former mixture are called crude, hard waters: they have an infipid tafte, are heavy upon the ftomach, and unfavourable to digeftion; and being likewife often purgative, the ufe of them is not without danger. It is, therefore, an object of confiderable importance to diftinguifh the quality of water; to difcover whether it be impregnated with any bodies which may communicate to it noxious properties; and to adopt means for purifying it from fuch a mixture.

Good wholefome water is generally diftinguifhed by the following characteriftics. It is very clear and limpid; no extraneous body alters its tranfparency; it has no fmell; it has a lively, frefh, and almoft pungent tafte; it boils readily, and without lofing its tranfparency; it entirely diffolves foap, in fuch a manner as to produce a homogeneous fluid, without clouds or lumps; it boils leguminous vegetables without hardening them: if tried by an addition of thofe liquors that are named *re-agents*, fuch as alkalis, and folutions of mercury and filver with nitre, it lofes neither its purity nor tranfparency; or at leaft if it fuffers any change of this kind, it is almoft imperceptible. Laftly, it paffes eafily through the ftomach and the inteftines, and is favourable to digeftion. Spring or river water, which filtrates or flows through fand, is in continual motion

and is not polluted with the putrefaction of animal or
vegetable fubftances,—is found to poffefs all thefe pro-
perties: but filth muft not be conveyed into it by few-
ers; the channel muft not be filled up fo as to divert
or flacken its courfe; nor muft hemp be fteeped, or foul
linens wafhed in it, &c. On the contrary, water which
ftagnates in fubterraneous cavities, which iffues from a
calcareous or gypfeous foil, which has no current, which
is overgrown with plants or crawls with infects, which
is very fhallow, with a foft muddy bottom, confifting
of putrid vegetables; all fuch water exhibits quite diffe-
rent qualities. Its tafte is infipid or even naufeous; it
has the fmell of a mouldy or putrid fubftance; it is often
green or yellowifh; green or brown flakes of matter,
the remains of putrefied vegetable fubftances, are feen
fwimming in it; it turns vegetable blues to green; it
becomes dark and muddy when boiled; forms clouds
with foap, and hardens all kinds of pulfe; the re-agents
caufe it to give precipitates in greater or lefs abun-
dance; it oppreffes the ftomach, remains long upon it,
and retards digeftion.

Several means are ufed to correct thefe bad qualities,
which have been adopted entirely from the confidera-
tion of its phyfical and chemical properties.

1. Stagnant waters are put in motion by cutting out
for them a floping channel, expofing them to the action
of mills, caufing them to rife in fpouts through the air,
or to tumble down in cafcades. By thefe means the
putrid gas and fpiritus rector are made to evaporate,
extraneous matters are collected and depofited in the
bottom, and a confiderable quantity of air is attracted
into combination with the water.

2.

2. Marſhes and pools are cleanſed of all putrefying animal and vegetable ſubſtances: and this cannot be done without agitating their waters at the ſame time, which is alſo ſerviceable.

3. Water is filtrated through jars or fountains, the bottoms of which are covered with fine ſand and ſpon- ges: theſe need to be renewed from time to time. The bottoms of ſmall rivulets naturally covered with a bed of mud, are alſo laid with ſand and pebbles.

4. The above are means for purifying water by ſe- parating from it ſuch heterogeneous matter as may hap pen to float in it; but they cannot deprive it of any ſa- line ſubſtances that exiſt in it in a ſtate of ſolution. To ſeparate theſe from water, it muſt be boiled, left to ſet- tle and cool till it become clear, then filtrated through paper or pure ſand, and expoſed to the air in broad ſtone veſſels. After undergoing this proceſs, it may be drunk with ſafety. Ebullition frees hard water of the prin- ciple which occaſions its diſagreeable ſmell, and cauſes it to precipitate part of its calcareous ſalts: but to produce the laſt effect, the water muſt be boiled for half an hour, or for ſo long time as may be neceſſary to make it diſſolve ſoap, and to deprive it of the proper- ty of hardening pulſe.

5. If boiling be found inſufficient for purifying wa- ter of its calcareous ſalts, as ſometimes happens when it is ſtrongly impregnated; theſe muſt then be precipi- tated by boiling it with a ſmall quantity of potaſhes, or for want of potaſhes with common aſhes; the ſalts then fall to the bottom; and the water being ſuffered to ſettle, and expoſed to the air, acquires all the quali- ties which we wiſh it to poſſeſs.

6. We may alfo make ufe of fome fubftances to cor-
rect the difagreeable and noxious qualities of water,
fuch as fugar, meal, barley, corn, honey, pot-herbs, and
fome labiated aromatic plants. But thefe cannot, like
the former means, communicate to it the qualities of
pure water; they only fubftitute one tafte in the place
of another.

This account of the chemical properties of water re-
prefents it only as a powerful agent in combination, ca-
pable of entering into union with many natural bodies.
But in many of its combinations it fuffers a remarkable
alteration, which was not taken notice of till the
month of April 1784; and which is highly worthy of
the attention of chemifts.

Water has long been known to favour combuftion in
fome inftances, as in the enameller's lamp, in the in-
flammation of oils, in ftrong conflagrations, &c. Some
philofophers had thought themfelves authorized by thefe
facts to conclude, that water was fometimes changed
into air: but we are indebted to a few French academi-
cians for a more accurate account of thefe phenomena,
and of the nature of water. M. Lavoifier having ob-
ferved, with M. De la Place, that when inflammable
gas is burnt in a clofe veffel, by the help of vital air, a
product of pure water is obtained (a fact which was ob-
ferved almoft at the fame time by M. Monge, with the
moft accurate attention, in the laboratory of the fchool
of Meziere), concluded, that this product muft be
compofed by the combination of vital air with in-
flammable gas; and that thefe were the conftituent
principles of water. This theory, by which M. La-
voifier prefumed to deprive water all at once of the
character

character of a fimple elementary body, which it had fo long maintained, met with keen oppofition; and its author found himfelf under a neceffity of eftablifhing it by analytical as well as by fynthetic facts. He therefore attempted to decompofe this fluid, by exhibiting to it bodies, the affinity of which with one of its principles was fo ftrong, that they might be expected to feparate it from the other. Obtaining the affiftance of M. Meufnier, in his refearches on this head, thofe two philofophers read, in the academy, on the 21ft of April 1784, a Memoir, proving that water is not a fimple fubftance, but a genuine compound of the bafe of inflammable gas with that of vital air or the oxigenous principle; and that the two principles may be eafily feparated from each other. To obtain thefe two matters feparate, M. Lavoifier at firft employed the following procefs. In a fmall bell-glafs, above fo much mercury, he put a certain quantity of very pure diftiled water mixed with iron filings: Thefe filings were gradually calcined; an inflammable elaftic fluid was difengaged, and collected immediately above the mercury; and in proportion as thefe two phenomena appeared, the quantity of the water was diminifhed. By profecuting this experiment farther, the iron may be entirely calcined and totally decompofed; for the water, in M. Lavoifier's opinion, both occafions the calcination of the iron and gives out the inflammable gas. As the fluid is compofed of the oxigenous principle and the bafe of inflammable gas, the iron gradually depriving it of the former, combines with that principle to form a metallic oxide, and leaves the inflammable gas difengaged. Such was the firft experiment in which

this

this enlightened chemift accomplifhed the decompofi-
tion of water. But in thofe refearches which he profe-
cuted in conjunction with M. Meufnier, he followed a
much fhorter and more conclufive procefs. Placing
the barrel of a gun in a furnace, and heating it red-
hot, he dropped a certain quantity of water through it.
In this procefs, the water being reduced to vapour is
decompofed as foon as it comes into contact with the red
iron, and the oxigene which it contains becomes fixed
in the metal; as appears from the increafe of its weight
and the alteration of its fubftance. The bafe of inflam-
mable gas being fet at liberty, paffes quickly through
the gun-barrel, and is received into bell-glaffes placed
for that purpofe at the oppofite end. On a repetition
of their experiments, with all the precifion poffible,
thofe philofophers difcovered, that water contains about
fix parts of the oxigenous principle with one of the bafe
of inflammable gas; that of confequence this laft prin-
ciple conftitutes but a feventh part of the compound;
that it is thirteen times lighter than common air; and
that it occupies, when at liberty, fifteen hundred times
the fpace which it filled in its aqueous combination.

Water appears to act in the fame manner on many
other combuftible bodies, which it reduces with more
or lefs facility to a burnt ftate, and to afford uniformly
a quantity of inflammable gas. It may be decom-
pofed with zinc, charcoal, or oils; with the laft of
thefe, by dropping the water into boiling oil in a re-
tort, the neck of which is immerfed under the glaffes
of a common pneumato-chemical machine. But great
caution is neceffary to prevent the explofion that takes
place when the water rifes in the vacuum produced in
the

the neck of the retort by the ebullition of the oil. To determine certainly whether a combuſtible body, ſuch as a metal, a coal, &c. be capable of decompoſing water, immerſe a piece of it red hot into a veſſel of water, under a bell-glaſs filled with the ſame fluid, and the inflammable gas, which is always diſengaged whenever water is decompoſed, will be received into the glaſs. Theſe, namely, the decompoſition of water, and the production of inflammable gas, are the reaſons why bubbles ariſe when red iron is plunged into water, as has been obſerved by Meſſrs Haſſenfraſt, Stouttz, and D'Hellancourt, of the royal mineralogical ſchool of France. A ſimilar diſengagement of inflammable gas, the conſequence of the decompoſition of water, takes place when a piece of flaming charcoal is thrown into a quantity of this fluid.

Theſe are the newly diſcovered facts concerning the nature and compoſition of water. Meſſrs Lavoiſier and Meuſnier think, therefore, that this fluid is a compound of about ſix parts of the oxigenous principle and one of the baſe of inflammable gas, or, more accurately, of 0.86 of the former body, and 0.14 of the latter; that iron, charcoal, and oils, having a ſtronger affinity with the oxigenous principle than it has with the baſe of inflammable gas, enter into combination with it, leave the combuſtible elaſtic fluid diſengaged, and thus decompoſe water; that this liquid may be again formed by burning inflammable gas with vital air; that when this proceſs of combuſtion is carefully performed, a quantity of water is obtained, which anſwers preciſely in weight to the quantity of the two gaſes, by the

the combination of which it was produced; that in
many chemical operations, water is produced by this
combination; and that, therefore, if fpirit of wine and
oils be burnt under a chimney, proper for condenfing
their vapours, and fitted to the worm-pipe of a ftill,
the other end of which is joined to a receiver, a quan-
tity of water will be obtained almoft always greater than
that of the combuftible liquid which affords it; becaufe
the inflammable gas, difengaged from the liquid, com-
bines with the pure part of the atmofpheric air which is
decompofed during the combuftion.

Thefe difcoveries, and the theory founded upon
them, cannot but form one of the moft illuftrious æras
in the hiftory of natural philofophy. As it is of the
utmoft importance to confider all the confequences of
which it admits, with all poffible care, we fhall here
add a few obfervations, in order to convey more dif-
tinct and accurate ideas of it.

We have mentioned, that all aëriform fluids owe
their gafeous ftate to the matter of fire or heat combin-
ed with them. Inflammable gas depends on the fame
principle: For as the decompofition of water and its
change into inflammable gas always require an high
temperature, and as the more violent the heat applied,
the more rapid is the change; this gas, therefore, ap-
pears to acquire its amazing levity, and to affume the
aëriform ftate, in confequence of a confiderable quanti-
ty of heat being abforbed by its aqueous bafe; which is
the reafon why it can never be obtained but in a ftate of
extreme fufion. It becomes, therefore, neceffary to
beftow a particular name on this bafe of inflammable
                                                    gas,

gas, which when combined with the oxigenous princi-
ple, the bafe of vital air, is fufceptible of a folid form,
as in the inftance of ice. This bafe being confidered
as one of the effential principles of water, muft be dif-
tinguifhed by a name expreffive of that property. We
have adopted the word *hydrogene*, or *hydrogenous* prin-
ciple, as anfwering the purpofe. And we call water a
compound of the oxigenous principle, or the bafe of vital
air, and the hydrogenous principle, or the bafe of in-
flammable gas. And as there are many inflammable elaf-
tic fluids, fuch as alcohol, æther, volatile oils, &c. when
reduced to elaftic fluidity; we diftinguifh this principle
of water in its aëriform ftate by the name of *hydroge-
nous gas.*

In a future chapter we fhall have occafion to re-
view this important fubject; in this place it is fuf-
ficient to have fhown, that water is not a fimple, but
a decompofable body. Nature in her grand opera-
tions effects the feparation of principles with much
greater facility than art, and by many more ways
than art can ever difcover or adopt. It is in con-
fequence of its decompofition that water purifies
the atmofphere, by pouring into it ftreams of vital
air; that it contributes to the formation of faline
matters, of the principles of which pure air is al-
ways one; and that fuch a quantity of inflammable
gas is often difengaged from ftagnant waters, as fome-
times to overload the atmofphere, and to produce ig-
neous meteors, in confequence of being kindled by
the electric fluid in its ftruggles to maintain its equi-
librium. Laftly, This fine difcovery of the compo-

nent principles of water, its decompofition and re-compofition, illuftrates and explains many of the phe-nomena of nature, particularly the renovation of the atmofphere, the folution of metals, vegetation fermentation, and putrefaction ; as fhall be fhown more at large in feveral fucceeding chapters of this work.

C H A P.

CHAP. VIII.

Of Earth in general.

E philofophers of antiquity believed in the ex-
ftence of a fimple fubftance, the principle of
fs, gravity, drynefs, and fixity, and the bafe of
l bodies, to which they gave the name of *earth.*
pinion, founded folely on abftract reafoning and
iefis, has long been taught in the fchools, and is
aintained by a number of philofophers. Para-
gave the name of earth to all refidues obtained
ilyfis. But fucceeding chemifts following the
of Glauber, to examine refidues with as much
on as products, were foon convinced that thofe
ir from being pure earth ; and the opinion of Pa-
s was of confequence exploded. Boerhaave hav-
opted the notion of Paracelfus under fome re-
os, obferved, that after every analyfis, there re-
l a dry, infipid, heavy, colourlefs matter ; pof-
in fhort all the properties of earth. But thefe
s, when chemically examined, are found to dif-
onfiderably from one another, that they cannot,
iy propriety, be comprehended under one gene-
omination.
:her, as has been already mentioned in our account
iciples, admitted three different kinds of earth ;
ile, inflammable, and mercurial. Stahl confi-
he firft of thefe as the only genuine earth ; and

Macquer follows Stahl in thinking vitrifiable earth the pureſt and the moſt elementary.

In order to determine what judgement we ought to form on this matter, let us firſt examine attentively the properties which chemiſts agree in aſcribing to elementary earth. We find ſix which have been confidered as its diſtinguiſhing characteriſtics; namely, gravity, hardneſs, inſipidity, fixity, infuſibility, and inalterability. But all of theſe properties are found as well in the earth which forms the baſe of rock-cryſtal, quartz, and vitrifiable ſtones in general, as in clays. If then a number of ſubſtances, confiderably different from one another in many reſpects, be found to poſſeſs in common all the diſtinctive properties attributed to elementary earth, are we to confider them as ſo many ſimple primary earths? Or, ſhall we rather adopt the opinion of Stahl and Macquer, who, finding vitrifiable earth to poſſeſs in a more eminent degree all the properties of elementary earth, confider it as the only genuine primary earth, and the others merely as bodies formed by it in combination with different principles?

However plauſible this opinion, however reſpectable its authors, we cannot agree to confider vitrifiable earth as the only primary and elementary earth : 1. Becauſe this earth is not found in equal purity, even in all the ſtones in which Stahl and Macquer have themſelves admitted its exiſtence ; for inſtance, let quartz, rock-cryſtal, and flints, be examined and compared. 2. Becauſe all the diſcriminating properties of earth are found to belong to many ſubſtances which differ from vitrifiable earths only in poſſeſſing thoſe characteriſtics in a leſs eminent degree. 3. Becauſe vitrifiable earth has not

not been hitherto shown to be, as some chemists think it, the base of all solid matters, and of all the various kinds of earth.

We must adopt the following sentiments with regard to this matter. We observe many substances in nature possessing the properties of earths ; among which it is impossible to distinguish which is the most simple, as chemists find them all to possess nearly the same degree of simplicity : Besides, though one of these should be demonstrated to be more simple than the rest, it would be farther necessary to show that it enters into their composition, and constitutes the principle of their coherence and solidity. Wherefore, without presuming to determine what is properly elementary earth, we ought to admit the existence of various kinds of earths, and to study their properties, in order that we may recognise and distinguish them whenever chemical analysis offers any of them to our attention, combined or separate.

Chemists have long allowed the existence of several kinds of earthy matters : but the earlier classifications of these matters are faulty, because the properties assumed as characteristics were neither sufficiently numerous nor such as the substances were certainly known to possess. Such, for instance, is the division of earths into mineral, vegetable, and animal : for though the fixed residues obtained by a last analysis of organized matters, after lixiviating their ashes, be generally destitute of taste or smell, dry and indissoluble, yet these properties are not sufficient to entitle them to a place among the earths, as they possess neither inalterability, infusibility, nor simplicity. That substance which

M   composes

compofes the dry, folid bafe of animal bones, and
which, from its drynefs, infipidity, and infolubility,
had obtained the name of earth, has been, within thefe
few years, difcovered to be a true faline matter; as
we fhall fhow at large in the chemical hiftory of the
animal kingdom.   And we may with great probabi-
lity conjecture, that the infipid, infoluble parts, which
remain after the laft analyfis of other animal matters,
are of the fame nature.   The name metallic earths,
given to the calces of metals from their drynefs, and
becaufe fome of them are deftitute of fmell and inca-
pable of folution, does not properly belong to them;
for they are extremely fufible, and are, every one of
them, compounds, as fhall be afterwards fhown.

   The mineralogifts who have treated of the hiftory of
earths, have formed a more regular and accurate ar-
rangement of them than chemifts, who have confi-
dered this fubject only in general, fo far as it is con-
nected with the theory of chemiftry.   Moft of the mo-
dern philofophers who have attempted a claffification
of thefe matters, have characterized them by their
chemical properties, and have by that means thrown
much new light on the natural hiftory of the mineral
kingdom.   Wallerius, Cronftedt, and Monnet, have
given complete fyftems of mineralogy on this plan.
No chemift has made more numerous experiments on
earths and ftones than Pott, who has given a methodi-
cal arrangement of thofe bodies according to his own
obfervations.   The cohtinual labours of M. D'Arcet,
and the many analyfes of ftones made by Bergman
and Bayen, likewife merit the higheft praife.   We fhall
not attempt to exhibit and compare the feveral claffi-
                                                     fications

ications of thefe philofophers : our prefent objeƌ is
ɩot to detail the natural hiŀory of earthy matters, but
nerely to give the refults of the various refearches
which have been direƌed to this purpofe, with a view
o ſhow how many kinds there are of earth confidered
:hemically, and what are the charaƌeriŀic properties
f each kind.

Before proceeding farther, we muŀ obferve, that in
ur opinion no diŀinƌion ſhould be made between
arths and ŀones as to claſſification ; becaufe, when
ɾe confider them chemically, their fubŀance is the
ɩme, and only their aggregation different. Grit-ŀone,
ɩr inŀance, is but fand agglomerated by the force of
ggregation ; and fand is nothing but grit-ŀone, the
ɩtegrant parts of which are divided, and their aggre-
ation broken : the fame chemical properties are com-
ɩon to both.

Pott has divided earths and ŀones into four claſſes;
be vitrifiable, the argillaceous, the calcareous, and the
ypfeous. From later difcoveries it appears, that the
ɩbŀances hitherto known by the name of calcareous
arths, are true neutral falts : gypfeous ŀones have
een likewife difcovered to be a kind of faline fubŀance.
)nly two, therefore, of Pott's four claſſes of ŀones
ƌually belong to this divifion of natural bodies. Dr
ŀlack, whofe name will long mark one of the moŀ
lluŀrious æras in the annals of modern chemiŀry, by
xamining the bafe of Epfom falt, has difcovered it to
onfiŀ of a peculiar fubŀance, to which he has given
he name of magnefia, and claſſed it among the earths.
ɩnd his opinion has been unanimouſly adopted by
hemiŀs. Bergman, in analyfing ponderous fpar, has

M 4 difcovered

difcovered a peculiar earth, to which he has given
the name of *terra ponderofa*, and which we call
barytes.

We think thefe two laft fubftances ought to be diftin-
guifhed from earths properly fo called, for reafons to be
mentioned in the following chapters.

Thus we acknowledge as true earths none but fuch
matters as are abfolutely infipid, infoluble and infufi-
ble; and we diftinguifh, by a chemical examination,
what fubftances poffefs thefe properties. We admit
only two kinds of pure earth, equally fimple and e-
qually elementary.

The firft is that which conftitutes the bafe of rock-
scryftal, quartz, grit-ftone, flints, and of almoft all hard
-fcintillating ftones. Its chemical character is to fuffer
-no alteration even from the moft violent action of fire,
but to retain its hardnefs, tranfparency, and all its other
properties, to whatever degree of heat it be expofed.
It has been called *vitrifiable earth*, becaufe it is the on-
:ly fpecies of earth capable of forming, in combination
with alkalies, tranfparent glafs. But the name which
we prefer is *filice*, derived from that of filiceous earth,
which has been likewife given it becaufe it is conftant-
ly found in filices.

The fecond kind of earth which we confider as fim-
ple and pure, is pure argillaceous or *aluminous* earth.
The following properties confiderably different from
thofe of the former fpecies, form its peculiar character.
However pure, it is almoft always opaque; or if it en-
ter into any tranfparent ftones, thefe are much infe-
rior in tranfparency to filiceous ftones. It is always

disposed

difpofed in thin layers or laminæ, one above another. This difpofition correfponds to the cryftalline form which the former fpecies conftantly affects. Though it have no ftronger tafte than filiceous earth, yet it appears to act in fome manner on our organs; for it adheres to the tongue : which property naturalifts ex- prefs by faying, that *it flicks to the tongue.* Its force of aggregation is never fo ftrong as that of the former earth; for which reafon argillaceous ftones are never very hard, but may be broken by a blow with a ham- mer, without being cut or ftruck till they gave fire, like fcintillating ftones. The aggregative force of alu- minous earth being fo weak, renders it much more fuf- ceptible of combination than the other kinds; and ac- cordingly clays are much feldomer found pure than either quartz or rock-cryftal. From this it may be eafily inferred, why clays are almoft always coloured, and why few of them poffefs all the properties of the aluminous character in any eminent degree. Alumi- nous earth fuffers an alteration from the action of heat, to which filiceous earth is not liable. Inftead of re- maining, like the latter, unchanged when expofed to an ardent heat, it acquires an addition of aggregative force. It even affumes, in fuch circumftanees, fome of the properties of the filiceous earth, its hardnefs and a- verfion to combination. Water acts on aluminous earth, penetrates into its fubftance, adheres to it, and renders it foft and ductile. The exiftence of this combination appears from the difficulty with which the adhefion between thefe two fubftances is overcome, a ftrong and long continued heat being neceffary to effect a fepara-

tion

tion between them. The properties which this fpecies
of earth poffefs of compofing a pafte with water, and
becoming hard by the action of fire, render it a very
valuable material in the arts. Laftly, another proper-
ty of aluminous earth, which diftinguifhes it from the
filiceous ftill more than any of the former, is its capa-
city of entering into combination with a vaft number
of other bodies. So fubject is aluminous earth to the
affinity of compofition, that we find it a principle in
many compounds : and for this reafon we have enu-
merated and defcribed its properties more at large, in
order that it may be readily recognifed when obtained
in analyfes.

Thefe are the two kinds of earthy matter which ap-
pear worthy of being confidered as diftinct claffes, and
likewife as elementary fubftances, fince they have not
hitherto been decompofed. We are not fufficiently
acquainted with their origin, their formation and their
chemical properties, to pronounce as fome chemifts
have ventured to do, that one of them is fimpler than
the other, and that the other is nothing but a modifi-
cation of it. We cannot think ourfelves as yet autho-
rifed to advance, that the earth of rock-cryftal, or fili-
ceous earth, is the bafe of the aluminous, to conftitute
which it only needs to be attenuated, divided, and
wrought up in a particular manner; becaufe no chemift
has hitherto accomplifhed fuch a tranfmutation.

The two earthy matters, of the properties of which
we have here taken a general view, are feldom found
pure. Rock-cryftal is the only body which affords fi-
liceous earth in this ftate ; doubtlefs becaufe it is ex-
ceffively hard, and poffeffes the force of aggregation in

an high degree. Even there, it is often coloured by
the addition of fome extraneous fubftance. In quartz
it is ftill oftener altered by combination with fome co-
louring matters. But aluminous earth is ftill feldomer
found pure. In fhort, almoft all the earths and ftones
which naturalifts have diftinguifhed by different names,
are compounds of one or two fimple earths, or of faline
earthy fubftances, particularly of chalk and magnefia,
and fometimes of metallic matters, of which iron oc-
curs the moft frequently. To be convinced of this,
the reader needs only to caft his eyes on M. Monnet's
work, in which he has arranged ftones according to
their conftituent parts. That chemift's plan of arrange-
ment certainly merits no fmall praife; but while it ex-
hibits to view all the advantages which lithology can
derive from chemiftry, it at the fame time fhows how
far we are from an accurate and certain claffification of
ftones according to their chemical properties. This fub-
ject falls under our difcuffion in the following chapters.

P A R T.

PART SECOND.

The MINERAL KINGDOM: MINERALOGY.

SECTION I.

EARTHS *and* STONES.

CHAP. I.

*General View of Mineralogy: General Divifion of Mi-
nerals, and particular Divifion of Earths and Stones;
their various Characteriftics.*

A LL the bodies of the globe which we inhabit are
the objects of natural hiftory. So grand and
fublime is this fcience, when confidered with a view
to its general fcope! fo extenfive, when traced through
all the minute details into which it enters! Its ob-
fervation ranges from the meteorous phenomena of
the atmofphere to the changes which the matters de-
pofited in the ftrata of our earth undergo. All the
bodies fcattered over its furface, feas, lakes, rivers,
brooks, mountains, hills, valleys, plains, and caverns,
engage the attention of him who cultivates natural
ftory. The inanimate matter of the globe,

mimals inhabiting it, are equally the fubjects of his cu-
rious inquiry. The eye of genius may indeed com-
prehend the whole under one grand and extenfive
view: but humble fcrupulous obfervation confines it-
felf to minute detail; detaches the feveral parts of this
great whole; examines them apart from one another;
and thus divides the fcience into a number of feparate
branches. Many a man of invincible perfeverance, has
fpent his life in obferving and defcribing the manners
and operations of infects; and yet the fubject is not ex-
haufted.

The ftudent might therefore be deterred from the
ftudy of natural hiftory as too arduous and difgufting a
tafk; but thofe who have fuccefsfully profecuted the
fcience, have endeavoured to fmooth the difficulties of
the road to its attainment, by adopting means for ren-
dering it eafier of comprehenfion, and for affifting the
memory. Thefe are called *methods.* They confift in
arrangements of natural bodies, according to their pro-
perties. The characteriftics on which fuch a claffifica-
tion is founded ought to be ftriking and invariable.

One of the moft diftinct and important is a divifion
of all natural bodies into three great orders, which are
named *kingdoms ;* the mineral, the vegetable, and the
animal. Though the two laft of thefe feem to poffefs
fome leading properties in common, yet the difference
between them in point of form and exterior organiza-
tion is fufficient to make us confider them as feparate
orders.

Minerals compofe the folid mafs of the globe, or at
leaft its exterior cruft through which the efforts of men
have penetrated.   are in-

creafed only by the juxta-pofition of their parts and by
their attractive force. They are liable to no change
or variation, but fuch as are occafioned by the mutual
chemical action of bodies. And for thefe reafons they
are named *rude, inorganized, inanimate bodies.*

Vegetables, again, increafe by the operation of an in-
terior power: they have organs to refine and convert
into nourifhment, the juices which they derive from the
earth and the atmofphere. They fpring up, live, and
die; by a real generation, they propagate other bodies
like themfelves.

Laftly, Animals have organs more complex than thofe
of vegetables ; undergo more rapid changes; and are,
from their fuperior fenfibility and loco-motive powers,
much more fubject to the influence of furrounding bo-
dies.

The branch of natural hiftory which comprehends
the defcription of minerals, is named *mineralogy.* The
firft naturalifts who attempted claffification, arranged
minerals into a great many claffes. They admitted into
their arrangements, as fo many diftinct orders of mine-
rals, water, earth, fand, foft ftones, hard ftones, pre-
cious ftones, figured ftones, falts, fulphur, pyrites, mi-
nerals properly fo called, and metals, &c. Concerning
the progrefs that mineralogy has made fince the days of
Henckel, one of the firft who wrote in a methodical
manner on this department of natural hiftory, till the
appearance of M. Daubenton, whofe claffification is a
mafter-piece of accuracy and precifion, the reader may
confult the fyftems publifhed during that period; of
which a collection has been made by M. Mons

ñior [*]. He traces the fucceſſive improvements which the ſcience has received from the labours of Bromel, Cramer, Henckel, Wolterſdorff, Gellert, Cartheuſer, Juſti, Lehman, Wallerius, Linnæus, Vogel, Scopoli, Romé de Lille, Cronſtedt, De Borne, Monnet, Bergman, Sage; concluding with thoſe of M. Daubenton, who has accompliſhed all that could be wiſhed.

To make ourſelves acquainted with minerals, the firſt thing to be done is, to diſtinguiſh them into ſo many claſſes marked, each by ſome leading and diſtinct properties. We ſhall accordingly divide them into three. Under the firſt, we ſhall arrange thoſe ſtones and earths which are inſipid, inſoluble, and incombuſtible: under the ſecond, ſaline matters, having a ſtronger or fainter taſte, ſoluble in water, but incombuſtible: and, under the third, combuſtible ſubſtances inſoluble in water, and affording either a weaker or ſtronger flame when expoſed to the contact of fire, and at the ſame time not excluded from the acceſs of air.

Moſt of that part of the maſs of our globe with which we are acquainted conſiſts of earths and ſtones, which by their inſipidity, inſolubility, and incombuſtibility, are diſtinguiſhed from ſalts and inflammable bodies. Being regularly arranged in ſtrata or layers, they form mountains, hills, and plains; in mountains, they are diſpoſed either in huge ſhapeleſs maſſes, or in inclined horizontal layers; in plains, they are ranged in horizontal ſtrata, and covered with a bed of vegetative earth, produced by the accumulation of the remains of organized bodies. Often, however, ſuch large maſſes appear under a regular cryſtalline form in ſubterraneous cavities

ſt

[*] Minerd

or clefts. Moſt of them appear to h e vebeen formed by
the action of water; and it is continually dividing, at-
tenuating, and tranſporting them from one place to an-
other, and cauſing them to undergo many other chan-
ges. The natural hiſtory of theſe bodies conſtitutes
geology and *lithology*; the firſt treating of earths, the ſe-
cond of ſtones : But the two ſhould be united under one
claſs ; for all earths, excepting mould formed of the re-
ſidues of putrefied organized ſubſtances, are nothing but
ſtones, the aggregation of which is deſtroyed; and
ſtones again are formed by the union of earthy matters.

As there are a vaſt number of different kinds of
earths and ſtones, and a knowledge of them is high-
ly important in ſcience, as well as of great uſe in
the arts of life; philoſophers have ſought to diſtinguiſh
them from one another, and to give certain directions
for recognizing them wherever they occur. Ancient
naturaliſts did not think of dividing them into diſtinct
claſſes by their peculiar properties ; they were content
with deſcribing their general qualities, and followed
the order of their real utility or fancied value. Few of
the ſtones, therefore, mentioned by Pliny in his natu-
ral hiſtory, can now be found. Modern naturaliſts, ob-
ſerving the inconveniencies which attend this way of
deſcribing ſtones, have adopted a different method, in
order to eſtabliſh more obvious and laſting diſtinctions.
By obſerving their exterior and ſenſible properties, they
have arranged them into orders, genera, and ſpecies;
and have thus rendered the ſtudy more eaſy and ad-
vantageous.

Form, hardneſs, interior ſtructure, colour, and the
appearance they exhibit when broken, are the proper-
ties

ties which have been assumed as characteristics of earths and stones. To these some naturalists have added some of their chemical properties, especially the manner in which they are affected by fire, and the alterations which they suffer from acids. Let us here examine each of these properties, in order to understand the application of the general principles of lithology to the particular history of each of the genera of stones.

§ I. *Form confidered as a Characteristic of Stones.*

By the form of Stones, we understand the order and relative arrangement of their surfaces. The eye, at the very first glance on a collection of stones in a cabinet, perceives some of them to be of a regular geometrical figure, and others irregular masses; and observes, that regularity of form is in some instances accompanied with transparency, in some with opacity. Uniform observation has established it as a certain fact, that some species of stones always follow a particular mode of cryftallization; while others never appear but in irregular fragments. Several naturalists are of opinion, that all stony matters possess the property of assuming a cryftalline form; that some indeed possess it in a higher degree, and display it more invariably than others, but that all have some peculiar cryftalline form, which appears in their minutest particles. Such is the opinion of M. Romé de Lille, who has given a very copious and accurate history of the various cryftallizations of mineral substances *. That philosopher arranges the forms in which stones and all other mineral bodies ap-

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* Voyez la Criftallographie, 2d edit. Paris 1784.

pear, under the three denominations of determinate,
indeterminate, and confused cryftallization; and fhows
that there is no mineral fubftance but appears in one or
other of thefe ftates. But the truth is, fo many of them
affect the fecond mode of cryftallization, and the third
which is irregular and difficult to be diftinguifhed, that
we cannot gain a fufficient knowledge of the cryftalline
form of ftones, to authorize us to affume this as one of
their determinate charaðteriftics. Yet a number of
mineralogifts have formed general fyftems of lithology
and mineralogy on the principle of the regularity of
the form of ftones and minerals. Linnæus was the firft
that adopted this plan of claffification; and though he
has not entirely accomplifhed what he propofed in in-
troducing it, he at leaft directed the attention of fuc-
ceeding naturalifts to this property of ftones, and o-
pened the way that has led to all the difcoveries which
have fince been made on this fubject.

Such is the ftate of the prefent opinions concerning
the connection between cryftallography and the ftudy
of ftones and minerals. It explains the formation, and
fometimes the nature of thefe fubftances; and often
helps us to recognize and diftinguifh them from one
another: but it is not adequate to form the bafis of a
complete fyftem of mineralogy; it is only one of the
means to be employed in a claffification of minerals.
That eminent philofopher M. Romé de Lille, to whofe
labours we are indebted for fo much of our knowledge
concerning the peculiar forms of minerals, has not
founded his divifions of thefe bodies on their cryftal-
lization alone; inftead of making this form the great
principle of his claffification, he has only examined and
<div align="right">defcribed</div>

ibed the forms of mineral fubftances, claffed ac-
ng as their nature is faline, ftony, or metallic, and
dirig to the various combinations into which they

.

Hardnefs confidered as a Characterijlic of Stones.

ERE are a great many varieties of the aggrega-
if the component particles of ftones, of which li-
gifts have happily availed themfelves to diftin-
them from one another. Some have fuch ftrength
;gregation, and fuch a degree of hardnefs, that
yield not even to the beft tempered fteel, fuch as
or precious ftones. Others yield, and may be
rith inftruments, but not without difficulty, fuch
lartz, flints, hard grit-ftone, porphyry, and gra-
All of thefe ftones when ftruck fmartly againft a
blade produce a great many fparks; which pro-
has gained them the name of *fcintillating* or *ignef-*
ftones. Thofe fparks are minute pieces broken off
the fteel by its collifion with the ftones, and kind-
)y the heat which that collifion produces: that
is even fo intenfe, that the particles ftruck off from
teel are melted; and if they be collected on a
of white paper, and viewed through a magnifier,
will appear a parcel of half-calcined, half-vitrified
², like the drofs of forges. As the ftones which
i this manner on fteel are not all of the fame den-
but vary from the hardnefs of gems and rock-
ıl to the foftnefs of fand-ftones and vitrifiable brec-
·ccently formed, they muft afford a greater or a

fmaller

ſmaller quantity of ſparks, according to their reſpective
·grees of hardneſs.

There are a great many other ſtones, the aggregative
force of which is much leſs conſiderable, and which
are ſo ſoft that they may be eaſily cut with ſteel inſtru-
ments. Some of them, ſuch as marble and alabaſter,
are ſuſceptible of a fine uniform poliſh. The reſt, and
among theſe almoſt all argillaceous ſtones, admit only
of an imperfect poliſh, and always retain a dull, grea-
ſy appearance. We can at any time judge of the hard-
neſs of thoſe which poſſeſs this property in ſo moderate
a degree, and of the poliſh of which they are ſuſcepti-
ble, by wetting their ſurface. This ſimple proceſs com-
municates to them a momentary poliſh, which diſap-
pears in proportion as the moiſture evaporates.

It is to be obſerved, that many other ſtones beſide
the claſs of igneſcents produce a real ſcintillation when
ſtruck againſt ſteel; the reaſon of which is, that ſuch
ſtones are mixtures, containing ſome igneſcent parts.
Thus, ſome kinds of marble, and many calcareous
breccias, ſcintillate when ſtruck againſt ſteel; becauſe
they contain quartzoſe or flinty particles, intermixed
with the calcareous matter of which they are moſtly
compoſed.

The gravity of ſtones is neceſſarily proportioned to
their denſity. Some naturaliſts have conſidered this
property as of great importance in a claſſification of
ſtony matters. M. de Buffon conſiders ſpecific gravity
as one of the beſt means to enable us to diſtinguiſh
their particular character. But ſuch nice and accurate
experiments are neceſſary to determine the relative gra-
vities of ſtones, that this property cannot very well be
　　　　　　　　　　　　　　　　　　aſſumed

ffumed as the bafis of a lithologic method ; as plain-
nefs and fimplicity are highly requifite in the elements
f this branch of natural hiftory.

§ III. *Of the Fracture, Confidered as a Characteristic of*
Stones.

ALL ftones when broken difplay a certain arrange-
ment of their integrant parts, an interior contexture
and difpofition of their particles : but this, fo far from
being uniformly the fame, is infinitely diverfified
through the various claffes of ftony fubftances. To
his appearance which ftones prefent when broken, li-
thologifts have given the name of *fracture.* By obfer-
ring it, we may learn fome particulars which will be
f ufe to help us to diftinguifh their peculiar characters.
From a comparifon of fuch obfervations as have been
made on the interior ftructure of ftones, it appears
hat the feveral forts of fracture which they afford may
be reduced under certain heads. Some, like glafs, give
fmooth polifhed furfaces of a curved figure. This is de-
nominated the *vitreous fracture ;* it appears very dif-
tinctly in rock-cryftal, quartz, &c.
   Others again difplay furfaces, which are uniformly
fmooth, but in their figure alternately convex and con-
cave. The pieces may be neatly re-united. This is
called the *conchoidal fracture.* The correfponding con-
vexity and concavity are of various forms and fizes,
ride, narrow, round, oblong, deep, fhallow, &c. ;
s in feveral kinds of flint, jafper, agate, and petrofilex.
   There is another kind of ftones, which when broken
exhibit on their new furfaces an affemblage of round

projectin

projecting points, similar to grains of sand worn by wa-
ter : this is called the *granulated fracture*, and is very
observable in sand-stone. The size and other varieties
of the granulation constitute a number of distinctions a-
mong the stones of this species, serving to diversify
their characters. It is of this species we speak when
we say *fine* or *coarse grained* stones.

Lastly, There are many stones, the fracture of which
shows them to consist of smooth equal laminæ, disposed
one over another. Most of these are stones which bear
the name of *spars ;* and this is therefore denominated
the sparry fracture. These laminæ differ from one ano-
ther in extent, magnitude, thickness, transparency, and
position with regard to the axis of the crystallized stone;
for all the brilliant stones of this fracture exhibit a real
crystallization. Such as are dark and without lustre,
are only said to be *lamellated*, not sparry. The disposi-
tion of the laminæ, so much diversified in gems, and
calcareous, vitreous, and ponderous spars, is what oc-
casions the brilliancy of talc, and the several kinds of
feldt-spar, such as cat's eye, the avanturine, the labra-
dore stone, &c.

Some writers on this subject have arranged stones ac-
cording to their fracture, considered in conjunction
with their general form. In the year 1755, Cartheuser
published a system of mineralogy, in which he distin-
guishes stones into lamellated, fibrous, solid, and granu-
lated. But fracture alone is insufficient for the princi-
ple of a classification of stones ; it must be taken toge-
ther with the other characteristics which are examined
in this chapter *.

§ IV.

* See *L'Introduction a la Sciagraphie de Bergman,* par M. Mongez
le Jeune, page 21—F.

§ IV. *Colour considered as a Characteristic of Stones.*

THAT diversity of colours which we observe in stones, is occasioned by the various combustible or metallic substances which enter into their composition. Some-times the whole stone is of the same colour, and some-times variegated. The colouring part of stones is ge-nerally an accidental property of their nature; the pre-sence of which is not absolutely necessary, and which is liable to great varieties. There are indeed some kinds of stones which are pretty uniformly coloured, such as crystallized gems, schorls, and tourmalines; and in these the colour may be assumed as a characteristic. But as there are other species, and more especially va-rieties, of which it cannot be considered as a distinguish-ing property, lithologists therefore do not refer to it as a principle of classification.

Where colour may be considered as a characteristic property, we must distinguish between such stones as are all of one colour, and uniformly opaque, or uni-formly transparent, and such as are variegated with specks or veins; we must likewise take notice of the number of the colours which appear in any mass of stone; as in marble, for instance, there are sometimes no fewer than six or seven. According to the number and the disposition of the colours in those bodies, they are distinguished into stones of one, two, three, or four colours, variegated, spotted, veined, punctuated, cloud-ed, flowered, figured, herborised, &c.

N 4 § V.

§ V. *Alteration produced by Fire, confidered as a Cha-*
racteriſtic of Stones.

SEVERAL mineralogiſts, not content with obſerving
the exterior and more obſervable qualities of ſtones,
have extended their inquiries to their chemical proper-
ties, with a view to aſſume theſe as grounds of diſtinc-
tion. The particular alteration which any ſtone ſuffers
from the action of fire, is conſidered by many litholo-
giſts as an excellent mean for enabling us to aſcertain
its peculiar nature. They have obſerved, that fire de-
prives ſome ſtones, ſuch as quartz, of their tranſparen-
cy and hardneſs, without changing their nature or al-
tering their eſſential properties: others again, ſuch as
rock-cryſtal, have been found to loſe not even their
denſity and tranſparency when expoſed to the action
of heat : and others have been found fuſible and tranſ-
mutable into glaſs of various colours; of which kind are
ſchorls, zeolites, aſbeſtos, amianthus, and granites:
laſtly, there are ſtill many others, ſuch as calcareous
ſtones, which fire deprives of part of their weight, de-
ſtroying their conſiſtency, and rendering them ſoluble
in water, without melting them. Other experiments,
managed with more careful attention, have ſhown, that
ſome ſtones loſe their colour by fire, and that to ſome
it communicates a deeper ſhade. Such in general is the
reſult of the experiments of Meſſrs Pott, D'Arcet, and
many other chemiſts.

To complete the natural hiſtory of ſtones, it is neceſ-
ſary to take notice of theſe alterations, and to mark
their differences. It appears in general, that ſimple
ſtones

ones are liable to the leaſt alteration of their properes by fire: and that in proportion as a ſtone is more r leſs compound, it is more or leſs ſubject to ſuch an lteration. But ſtill the obſervation of theſe alterations innot be of much benefit to lithologiſts, as the expements neceſſary to diſcover them are tedious and diffiult; whereas the properties aſſumed as characteriſtics ı a claſſification of ſtones, ſhould be ſuch as are obvious ⁊ the eye, or at leaſt may be diſcovered by a ſimple xpeditious proceſs.

Sometimes, indeed, when we cannot determine the ıature of a ſtone by obſerving its external properties, ⁊e may have recourſe to the alteration which it ſuffers rom the action of fire, by means of the blow-pipe, an ngenious contrivance of Bergman's. Yet notwithlanding the ingenious ſimplicity of this invention, the ieceſſary apparatus is ſo incommodious, that it can carce be rendered portable, ſo as to be uſed in a lithoogic excurſion, but muſt remain confined to the laboɩtory *.

⁊ VI. *The Action of Acids conſidered as a Characteriſtic of Stones.*

Acids are the ſolvents ofteneſt uſed in chemiſtry.
Though

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* See Bergman on the blow-pipe, at the end of his Chemical Eſryʂ, tranſlated into Engliſh by Dr E. Cullen. London 1784.

All the apparatus neceſſary is a blow-pipe, a piece of charcoal, a ʂall ſilver ſpoon, and three ſmall phials containing ſoda, fuſible ſalt, ɒd borax; and the proceſs may be performed in any place where a ɑndle can be ſheltered from the wind. Complete apparatus for the ⁊rpoſe, in a box no larger than a book in twelves, are ſold at a Mr ɪɔʌʌp'ʂ, bookſeller, near the Strand, London.—I

Though we have not yet treated of thefe falts, yet we muft here fay a few words of the phenomena which ftones exhibit when brought into contact with them. The greater part fuffer no alteration from acid falts; but fome difplay a very obfervable motion, and an a-gitation fomewhat like a flight ebullition, if a drop of the nitric acid be caufed to fall through a glafs-tube on their furface. This phenomena bears the name of *ef-fervefcence*. It is owing to an aëriform fubftance, which being difengaged from the ftone by the action of the acid, rifes through the acid in a number of fmall bub-bles. That elaftic fluid is itfelf a peculiar acid, difenga-ged by the more active acid poured on the ftone, and is the product of an actual decompofition. All calca-reous ftones exhibit this effervefcence when brought into contact with acids: the nitric acid produces the moft powerful effects, and is moft commonly employed on fuch occafions. The difengagement of an aëriform acid is a proof that the matter from which it iffues is a faline combination: But as this combination is infoluble, and without any difcernible tafte, and as it compofes moft of the exterior layers of the globe of the earth, na-turalifts always confider it as a ftony fubftance.

Stones may therefore be divided into effervefcent and non-effervefcent. And a fmall phial full of nitric acid becomes of confequence a neceffary article in ex-curfions to examine and collect ftones. This, together with the magnifier and the fteel, are all the inftruments which the lithologift needs to carry with him on fuch an expedition.

Since Bergman recommended the examination of *ftones* by fire with the blow-pipe, they are alfo affayed

with

with foda, borax, and fufible falt, which act varioufly upon them according to the differences of their nature, but generally produce fufion in fome degree, together with other phenomena. We fhall explain this method of analyfing ftones more particularly in the chapter in which we treat of all the methods of effecting that analyfis.

CHAP.

CHAP. II.

The Lithologic Method of M. Daubenton, extracted from his Tableau de Mineralogie.

NONE of all the mineralogifts who have attempted a methodical arrangement of ftones, has given a more accurate or perfpicuous claffification than M. Daubenton. The ingenuity with which this naturalift, fo defervedly celebrated, has contrafted the characteriftics of thofe fubftances, renders his method more accurate and ufeful than any before propofed. The properties which he has affumed as characteriftics are all invariable and obvious. They are chiefly regularity or irregularity of form; the various degrees of tranfparency and opacity; confiftency or hardnefs; the polifh of which ftones are fufceptible; the form or refpective arrangement of the integrant parts, which occafions the vitreous, conchoidal, granulated, lamellated, and fpathofe fractures; colours, in thofe inftances in which they are not accidental; a dufky, brilliant, or mildly lucid furface. As it would be impoffible to improve upon the perfpicuity and accuracy of M. Daubenton's fyftem, all that we fhall here do, is, to lay before our readers his divifion of earths and ftones, as he has exhibited it in his *Tableau Methodique de Mineraux**.

FIRST

* *Tableau Methodique des Mineraux, fuivant leurs differentes natures, et avec des characteres diftinctifs, apparens ou faciles à reconnoître; par M. Daubenton, &c. Paris, chez Demonvile, Pierres, Debure, Didot Pains, &c. in-8. de 36 pages.*

FIRST ORDER

OF MINERALS.

SANDS, EARTHS, AND STONES *.

Thefe Subftances melt not in Water like Salts, burn not like Combuftible Bodies, nor difplay the luftre of Metallic Matters.

CLASS FIRST.

Stones which give Fire with Steel.

Genus I.   Quartz.

Cryftalline Subftance, Fracture vitreous, not lamellated.

Species I. Opaque, or femi-tranfparent Quartz.

Varieties.
{
1. greafy.
2. grained.
3. lacteous.
4. foliated.
5. cryftallized.
}

Species II.

---

* Here we give only part of M. Daubenton's table; but in the hiftory of falts and combuftible bodies, his divifion of thefe matters fhall be introduced. As we follow that table fo faithfully as to copy even

the

Species II. Tranfparent Quartz, ROCK CRYSTAL,

Two pyramids of fix fides, with or without a fix-fided prifm between them.

Varieties.

1. cryftallized.
2. rough.
3. white.
4. red. *BOHEMIAN RUBY.*
5. yellow. *OCCIDENTAL TO-PAZ.*
6. ruddy, or blackifh. *SMOAKY TOPAZ.*

7. green
8. blue. *WATER SAPPHIRE.*
9. violet. *AMETHYST.*
10. iridefcent.

Species III.

---

the charaɛters in which the feveral parts of it are printed, we fhall here fubjoin the beginning of the Author's prefatory account of it.

" Since the year 1779, this table has been exhibited in manufcripb
" in the Hall of the Royal College, during the courfe of my leɛtures,
" and many copies of it have been taken. I have made repeated al-
" terations, according as I received from others, or acquired by my
" own obfervation, new information refpeɛting mineralogy. I have
" even given up for a time my defign of exhibiting on my table the
" refults of a chemical analyfis of the different minerals it contains as
" I had begun to do, becaufe there have not yet been a fufficient num-
" ber analyfed. My chief objeɛt in drawing out this table was to fa-
" cilitate the ftudy of mineralogy. The beft means for diffufing the
" knowledge of the fciences is to fimplify their elements : Methodical
" arrangements contribute to this end. For though it be impoffible
" to include all the properties of natural bodies, in any claffification of
" them, yet fuch a claffification is ufeful, convenient, nay even ne-
" ceffary.

s III. Quartz in agglutinated fragments, Grit-
ftone, or Siliceous Grit,

granulated fracture.

Varieties.
1. hard grit-ftone
2. friable
3. Levant grit-ftone. *Very fine grain*
4. filtering ftone. *Porous*
5. glittering
6. veined
7. difplaying figures of plants
8. coarfe grained.

s IV. Quartz in feparate grains, SAND,

vitreous furface.

Varieties.
1. angular
2. round
3. moving
4. fluid.

Species

In the firft volume of my Lectures on Natural Hiftory,
the prefs, I fhall give a particular explanation of my table,
h both the advantages and defects of my arrangement of
s will be pointed out. Here I fhall only obferve, that mine-
in this table diftributed into orders, claffes, fpecies, and va-
The diftinctive characteriftics of each article are printed in
haracters.
names in Roman capitals are thofe which I think moft fuit-
the things which they are ufed to denote: Thofe in Italic
are fynonyma; the ufe of which is attended with inconve-
, and which are inferted only that the knowledge of the mat-
ich they denote may be the eafier acquired.—F.

Species V. Quartz in concrete Maſſes.

Sandy and quartzofe Breccias, or Pudding Stones.

Genus II.   Semi-tranſparent ſtones,

vitreous fraɛ̆ure, ſometimes conchoidal.

Species I. Agates,

of all colours, except milk white, fine red, orange, and green.

Varieties.
1. clouded
2. punɛ̆uated
3. ſpotted
4. veined
5. onyx
6. irifed
7. preſenting the figures of herbs
8. exhibiting the appearance of mofs.

Species II. Chalcedonies,

laɛ̆eous tranſparency.

Varieties.
1. reddiſh
2. bluiſh
3. veined
4. onyx
5. iridefcent. OPALS
6. round and folid. GIRASOLS
7. round and hollow. ENHI-DRALS
8. in ſtalaɛ̆ites
9. in fediment
10. hydrophanes.

Species

s III. Carnelians,

beautiful red.

Varieties.
1. pale
2. punctuated
3. onyx
4. exhibiting figures of herbs.
5. in ftalactites.

s IV. Sardonyx,

orange colour.

Varieties.
1. pale
2. veined
3. onyx
4. prefenting figures of herbs
5. blackifh.

s V. Flints.

gray, white, reddifh, blackifh.

Varieties.
1. with tubercles
2. in layers.

s VI. The Prafeum,

green.

Varieties.
1. green
2. clouded
3. fpotted.

s VII. Jade.

greafy polifh.

Varieties.
1. whitifh
2. olive coloured

L.

Species VIII. Petrofilex,

> *tranfparency of wax, conchoidal fracture.*

> Varieties. {
> 1. white
> 2. reddifh
> 3. veined.

Genus III. Opaque Stones,

vitreous fracture, fometimes conchoidal or dufky.

Species I. Miln Stone,

> *more or lefs porous.*

> Varieties. {
> 1. porous
> 2. denfe, or full.

Species II. Pebbles,

> *concentric layers.*

> Varieties. {
> 1. fpotted
> 2. veined
> 3. onyx
> 4. oculiform
> 5. exhibiting figures of herbs
> 6. concreted into breccias. PUD-
>   DING STONES.

Species III. Jafper,

> *vitreous fracture, often dufky, without concenti*
> *layers.*

> Varieties. {
> 1. green
> 2. red
> 3. yellow

4. bro

Varieties. {
4. brown
5. violet
6. black
7. grey
8. white
9. clouded
10. fpotted
11. veined
12. onyx
13. flowered
14. univerfal
15. fragments united in breccias.

1s IV. Scintillating Spar. FELD-SPATH.

Feld-Spath, regularly cryftallized.

Varieties. {
1. in oblique (angled) prifms, of four fides
2. in fix-fided prifms, with fummits of two planes
3. in ten-fided prifms, with fummits of four facets.

Feld-Spath in confufed cryftals.

Varieties. {
1. white
2. pearl-grey. FISH'S EYE
3. red
4. red, with brilliant fpangles. NATURAL AVANTURINE
5. green
6. blue
7. violet
8. with green and-blue ftripes, *LABRADORE STONE*
9. with ftripes of various colours, CAT'S EYE.

O 2   Genus

Genus V. Cryſtal Gems,

*tranſparent and lamellated, not electrifiable by b
lone witbout friction.*

Species I. Red,

Varieties. { 1. Garnets
   cryſtallized with 12, 2ₐ
   facets. There are ₍
   low, and brown, &
   nets
2. The balaſs-ruby,
   roſe-colour, octahedral ₍

Species II. Red and orange,

Varieties. { 3. Spinell ruby,
   *fire-coloured, cryſtalliₐ
   the balaſs-ruby*
4. Vermilion,
   cryſtallized like the garₜ
5. Hyacinthe-la-belle,
   *cryſtallized under 4 bₑ
   ſides with ſummits,
   4 rhomboidal facets.*

Species III. Orange-coloured,

Variety. 6. Hyacinths,
   *cryſtallized like the by
   la-belle*

Species IV. Yellow,

Varieties. { 7. Oriental topaz,
   *cryſtallized in 2 pyramₑ
   facets*
8. Saxon topaz,
   *cryſtallized in priſms
   ſides, with ſummits
   facets.*

Species V. Yellow and green.

| | Variety. | 9. Peridots, *CHRYSOLITES.* *cryſtallized in priſms of 6 ſides,* *with pyramids of 6 faces.* |

Species VI. Green.

| | Variety. | 10. Peruvian emerald, *cryſtallized in 6 ſided priſms.* |

Species VII. Green and blue.

| | Variety. | 11. Aqua-marina, *cryſtallized like the Saxon to-* *paz.* |

Species VIII. Blue.

| | Variety. | 12. Oriental ſapphire, *cryſtallized like the oriental to-* *paz.* |

Species IX. Indigo.

| | Variety. | 13. Indigo ſapphire, *cryſtallized like the oriental to-* *paz and ſaphire.* |

Species X. Red and violet *.

| | Varieties. | 14. Syrian garnet, *cryſtallized like the garnet* 15. Oriental ruby, *cryſtallized like the oriental to-* *paz and ſapphire.* |

O 3   Genus

---

* Gems formed without colouring matter are white. *Note by M.* *Daubenton.*

Genus VI. Tourmalins, Cryſtal Gems,

compoſed of laminæ perpendicular to the axis of the cry
ſtal, and electrifiable by heat alone without fri
tion.

Varieties.
{
1. Braſilian ruby,
red, in four-ſided priſms, w
* pyramids of four facets*
2. Braſilian topaz.
yellow, cryſtallized like
* Brazilian ruby.*
}

Genus VII. Tourmalins,

electrifiable by heat alone without friction, laminæ
perpendicular to the axis of the cryſtal.

Varieties.
{
1. Tourmalins of Ceylon,
tranſparent, orange-coloured,
ry little channelled on the
face
2. Spaniſh tourmalins,
tranſparent in a ſtrong l
orange coloured, very
channeled
3. Tourmalins of Tyrol,
fiſſures traverſing the priſ
4. Tourmalins of Madaga
SHORLS OF MADAGA
opaque, black
5. Lenticular tourmalins
6. Peridots of Ceylon,
yellow and green, very
channelled
7. Peridots of Braſil,
yellow and green, very
channelled
}

8.

Varieties. { 8. Brafilian emerald, *green*
9. Brafilian fapphire, *blue* *.

Genus VIII. Schorls,

electrifiable by heat without friction, opaque cryftals, or long green femi-tranfparent needles.

pecies I. Cryftallized Schorls,

Varieties. {
1. in oblique prifms, with four fides
2. in fix-fided prifms PIERRE DE CROIX
3. in fix-fided prifms, with fummits of 2 facets, or pyramids of 3 or 4 facets
4. in prifms of 8 fides, with fummits of 2 facets.

pecies II. In articulated fragments.

Varieties. {
1. fpathofe fchorl, *ftriated with fparry ftripes*
2. in maffes. SCHORL PASTE *brilliant points in the fracture.*

Genus IX. Azure Stone,

opaque and blue.

Varieties. { 1. purplifh blue
2. blue.

O 4 CLASS

All thefe tourmalins, excepting the lenticular, are cryftallized in fided prifms, with fummits of three or fix facets. *Note by M.* *raton.*

CLASS SECOND.

*Earths and Stones which neither give Fire with Steel,
nor effervesce with Acids.*

———————————

Genus I. Clays.

*when moist they are ductile ; when dry they are polish-
ed by a slight rubbing with the finger.*

Species I. Clays abfolutely infufible.

Varieties $\left\{\begin{array}{l}\text{1. ufed to make pots for the}\\ \quad\text{glafs-houfe}\\ \text{2. for tobacco pipes.}\end{array}\right.$

Species II. Clays partly fufible.

Varieties. $\left\{\begin{array}{l}\text{1. for porcelain}\\ \text{2. for Englifh potter}\\ \text{3. for ftone-ware.}\end{array}\right.$

Species III. Clays entirely fufible.

Varieties. $\left\{\begin{array}{l}\text{1. for common pottery.}\\ \text{2. for delft-ware}\\ \text{3. for Dutch tiles}\\ \text{4. for tiles}\\ \text{5. for bricks.}\end{array}\right.$

Genus

Genus II. Schiſtus,

argillaceous and foliated fracture.

Varieties.
1. black ſtone
2. common ſchiſtus
3. writing ſlate
4. poliſhing ſtones
5. green ſtone
6. hone
7. fragments united in breccias.

Genus III. Talc,

poliſhed gliſtening laminæ, without ſpathoſe fracture.

Species I. Talc in large leaves.

Variety. Muſcovy talc.

Species II. In ſmall leaves.

Variety. Mica.

Genus IV. Steatites,

feel greaſy, like tallow.

Species I. Steatites in layers.

Varieties.
1. fine French chalk (de Briançon)
2. coarſe French chalk (de Briançon.)

Species II. Compact Steatites.

Varieties.
1. ſoap rock (Pierre de lard)
2. Spaniſh chalk.

Species III. Lapis Ollaris.

Varieties.
1. Como ſtone
2. foliated lapis ollaris.

Genus

Genus V. Serpentines,

the polifh and colours of marble.

Species I. Opaque Serpentines.

Varieties. { 1. fpotted
2. veined.

Species II. Semi-tranfparent Serpentines.

Varieties. { 1. granulated
2. fibrous.

Genus VI. Amianthus,

filaments not calcinable, leaves or flakes lighter than water.

Species I. Amianthus with foft fibres.

Varieties. { 1. with long fibres
2. with fhort fibres.

Species II. Amianthus with hard (brittle) fibres.

Varieties. { 1. Afbeftos, eafily divifible into parts (mur)
2. Afbeftos, not eafily divifible into parts (non **🀄🀄**)

Species III Amianthus in flakes or leaves

Varieties. { 1. foffil leather
2. foffil cork.

Genus VII. Zeolite,

cryftallized in divergent radii, or tranfmutable into a gelly by folution in acids.

Species I. Cryftallized Zeolite.

Species

es II. Compact Zeolite.

$$\text{Varieties.} \begin{cases} 1.\ \text{white} \\ 2.\ \text{blue} \\ 3.\ \text{red.} \end{cases}$$

Genus VIII.   Fluor Spar,

gments with triangular faces, all inclined to each 'ther.

ies I. Fluor Spar in cryftals.

$$\text{Varieties.} \begin{cases} 1.\ \text{octahædrons} \\ 2.\ \text{cuneiform octahædrons} \\ 3.\ \text{with 14 faces} \\ 4.\ \text{cubical.} \end{cases}$$

ies II. Fluor Spar in irregular Maffes.

Genus IX.   Ponderous Spar,

rhomboidal fragments, the lateral faces perpendi- cular to the bafes.

ies I. Cryftallized Ponderous Spar.

$$\text{Varieties.} \begin{cases} 1.\ \text{in rhomboidal plates} \\ 2.\ \text{in octahædrons with acute fummits} \\ 3.\ \text{in octahædrons with obtufe fummits} \\ 4.\ \text{in hexagonal plates with a-cute fummits} \\ 5.\ \text{in hexagonal plates with ob-tufe fummits} \\ 6.\ \text{in tables} \end{cases}$$

lenticular)

Species II. Ponderous Spar cryftallized confufedly

BOLOGNA STONE.

Genus X. Ponderous Stone. *TUNGSTEN,*

*refembling Fluor Spar in the form of its fragments,
but much heavier ; it becomes yellow in acid* .

CLASS THIRD.

Earths and Stones which effervefce with Acids .

Genus I. Calcareous Earths.

· *Effervefcence with Acids.*

Species I. Compact.

Variety. Chalk.

Species

---

* Though modern chemifts confider thefe fubftances as neutral
falts, formed by the union of chalk with the carbonic acid, we fub-
join them here after the earthy matters, in order to give a connected
view of M. Daubenton's method. Naturalifts, who employ in their
arrangements none but exterior and ftriking characteriftics, muft con-
fider thefe fubftances as genuine earths: but in the hiftory of faline
matters, they will be viewed in a different light. F.

ies II. Spongy.

   Variety. Stone-marrow,

ies III. In powder.

   Variety. Foffil Flour.

ies V. Confiftency of cream.

   Variety. Lac lunæ.

ies V. Figured.

   Variety. Congealed.

———— ———— ———— ————

Genus II.   Calcareous ftones,

indifferent colour and polifh.

ies I. Coarfe grained.

   S P E C I M E N.
   Limeftone from Arcueil.

ies II. Fine grained.

   S P E C I M E N.
   The Thunderftone.

———— ———— ———— ————

Genus III.   Marbles.

Granulated fracture, fine colour and polifh.

ies I. Marbles of fix colours.

          Varieties

Varieties. { White, grey, green, yellow, red, and black.
SPECIMEN.
Marble from Wirtemberg.

Species II. Marbles of two colours.

Varieties. { 15 in number, formed by the combination of 6 colours, 2 together.
SPECIMEN.
white and grey.
Marble of Carrara.

Species III. Marbles of three colours.

Varieties. { 20 in number, formed by the combination of 6 colours, 3 together.
SPECIMEN.
grey, yellow, and black.
Lumachello.

Species V. Marbles of four colours.

Varieties. { 15 in number, formed by the combination of 6 colours, 4 together.
SPECIMEN.
white, grey, yellow, and red.
Brocatello from Spain.

Species V. Marbles of five colours.

Varieties. { 6 in number, formed by the combinations of 6 colours, 5 together.
SPECIMEN.
white, grey, yellow, red, and black.
Breccias of Old Castle.

Gen

Genus IV.   Calcareous Spar.

Regular form, spathose fracture.

Species I.   Cryſtallized calcareous ſpar.

Varieties.
{
1. obtuſe rhomboidal figure.
   Iceland Spar.
2. lenticular rhomboidal figure
3. lenticular rhomboidal figure
   6 triangular faces
4. acute rhomboidal figure
5. with 12 pentagonal faces
6. with 3 triangular faces
7. ſix-ſided priſm
8. ſix rhomboidal ſides, with 6 faces
   lozenge-wiſe
9. with 12 ſcalene triangular faces
10. with 12 faces of 4 or 5 ſides, and
    6 quadrilateral facets
11. with 6 hexagonal faces, and 12
    facets of four ſides.
}

Species II.   Striated calcareous ſpar.

Varieties.
{
1. with parallel ſtriæ
2. with divergent ſtriæ.
}

Genus V.   Concretions.

Succeſſive coats.

Species I. Stalactite Concretions.

Varieties.
{
1. in columns
2. tabular
3. reſembling alabaſter.
}

Species

Species II. Concretions by incruftation.

Specie III. Concretions by fediment.

Varieties. $\left\{\begin{array}{l}\text{1. by horizontal fediments}\\ \text{2. by rounded fediments.}\end{array}\right.$

CLASS FOURTH.

Mixed Earth and Stones.

Mixed earths.

Genus I.   Sand and Clay.

Species.   Sand for founders.

Variety.   Sand from Fontenai-aux-rofes.

Genus II.   Sand and calcareous earth.

Genus III.   Clay and calcareous earth.

Species.   Marle.

Varieties. $\left\{\begin{array}{l}\text{1. marle, Armenian bole}\\ \text{2. marle, terra figillata}\\ \text{3. ftone for taking fpots out of cloth}\\ \text{(pierre a detacher)}\\ \text{4. fuller's earth}\\ \text{5. porcelain earth}\\ \text{6 pipe clay}\\ \text{7. potter's clay (terre a faiance)}\\ \text{8. white marle}\\ \text{9. foliated marle}\\ \text{10. marle for manure}\end{array}\right.$

Mixed

Mixed Stones,

OF TWO GENERA.

ınd fcintillating fpar - - Granitln.

ınd fchorl - - - - Graaitello.

ınd fteatites - - - Quartofe fteatites.

ınd mica - - - - Micaceous quartz.

rent quartz and mica - Micaceous cryftal.

n grit and gem-ftone - { 1. Garnet on grit-ftone.
 { 2. Garnet in grit-ftone.

n grit and mica - - Micaceous grit.

n grit and calcareous mat- { 1. cryftallized grit.
 { 2. grit in ftalaÂ¢tites.

ın fand and opaque ftone { fandy and filiceous brec-
 { cias.

n fand and fchiftus - - { fcintillating fchiftus.
 { *HORNSTONE. TRAP*.

n fand and zeolite. - - fcintillating zeolite.

ting fpar and fchorl pafte ophites.

nfparent ftone, with o- { jafperated agate, or ag-
 ue ftone { gatized jafper.

Schorl

Schorl and mica - - - - { micaceous fpathofe fchorl.

Schiftus and mica - • - • micaceous fchiftus.

Schiftus and marble - - - . Florence ftone.

Serpentine and marble - - {
1. green Egyptian marble.
2. fea green marble.
3. green antique marble.
4. green marble of Suza.
5. green marble of Varalta.

Ponderous fpar and calcareous matter } alkaline ponderous fpar.

OF THREE GENERA.

Quartz in fand, fchiftus and mica rough wheat-ftone.

Quartz, gem, and mica - - garnet rock.

Quartzofe pafte, fcintillating fpar in fmall fragments, and fchorl } porphyry.

Quartzofe pafte, fcintillating fpar in large fragments and fchorl } ferpentine. *hard ferpen-tine.*

Quartz, fchorl, and fteatites - - tuberculous rock.

Quartz, fcintillating fpar, and fchorl } granite

OF FOUR GENERA.

Quartz, fcintillating fpar, fchorl, and mica } granite.

ISISTING OF MORE OR FEWER ⎱ univerſal brecciaſ.
ENERA, UNITED IN BRECCIAS ⎰

DOUBLE BRECCIAS.

Varieties. ⎰ 1. Fragments of porphyry, and paſte
　　　　　　　 of porphyry.
　　　　　　 2. Fragments of granite, and ſchorl
　　　　　　　 paſte.

VOLCANIC PRÓDUCTS*.

us I. Lavas, or Matters formed by Volcanoes;
　　　　volcanic Matters.

ecies 1. Porous Scoriæ.

Varieties. ⎰ 1. in irregular maſſes.
　　　　　　 2. in ſtriped maſſes.
　　　　　　 3. in the form of ſtalactites.
　　　　　　 4. in fragments. LAPILLO.
　　　　　　 5. in ſmall fragments.
　　　　　　　　 POUZOLANA.
　　　　　　 6. in duſt.
　　　　　　　　 VOLCANIC CINDERS.

　　　　　　　　　　　　　　Species

L. Daubenton places volcanic products at the end of minerals,
t ranking them under any of the four orders of which his me-
ſonſiſts. As their hiſtory is uſually ſtudied along with that of
I have a

Species II. Bafaltes,

  compaćt and fcintillating, blackifh cinereous fraćture,
    &c. with brilliant points, without fmall plates, like
    thofe of the fcintillating fchiftus.

$$\text{Varieties.} \begin{cases} \text{1. in irregular maffes.} \\ \text{2. in balls.} \\ \text{3. in tables.} \\ \text{4. in prifms of 3, 4, 5, 6, 7, 8, or 9} \\ \quad \text{fides.} \\ \text{5. in articulated prifms.} \end{cases}$$

    Species III. Glafs.

$$\text{Varieties.} \begin{cases} \text{1. in feparate fibres.} \\ \quad \text{GLASS GALL.} \\ \text{2. in agglutinated fibres.} \\ \quad \text{PUMICE STONE.} \\ \text{3. in compaćt maffes.} \\ \quad \text{VOLCANIC SCORIA.} \\ \textit{LAPIS OBSIDIANUS.} \end{cases}$$

  Genus II. Volcanized Matters; that is to fay, mat-
ters, altered by the heat of volcanoes, *appearing to
have been baked, calcined, melted, or vitrified.*

    Species I.   Granite.
          II.   Garnet
          III.   Hyácinth.
          IV.   Mica.
          V.   Peridot.
          VI.   Quartz.
          VII. Schorl.
          VIII. Scintillating fpar.
          IX.   Calcareous Subftances.
          X.   Baked Earths, Tripoli

STONES, *with the nature of which we are not yet suf-*
ficiently acquainted to reduce them under certain Claf-
fes.

Jargon of Ceylon.

> *cryftals in rectangular prifms, with pyramids of 4*
> *triangular faces.*

The name of Jargon appears to be given to many
ftones, the particular ftructure of which is hitherto un-
known.

Macles,

> *in fquare or cylindrical prifms, the tranfverfe fec-*
> *tion of which exhibits a blue crofs.*

The macle has been confidered as a fchorl; but the
opinion has not been proved.

White Cryftals,

> *in flattened prifms with 10 fides, with two fummits*
> *of four faces, one of which forms a concave, the*
> *other a convex angle.*

Violet or green Cryftals.

> *rhomboidal, with two facets inftead of two oppofite*
> *angles.*

Thefe white, violet, and green cryftals, have obtain-
ed the name of Schorls, although they do not appear
to be of the fame nature with fc]

C H A P. III.

Of the Classification of Earths and Stones according to their Chemical Properties.

THOSE chemifts who have engaged in the the ftudy of minerals, have endeavoured to eftablifh diftinctions among them, founded on their chemical properties. And though a fufficient number of earths and ftones has not yet been examined, to enable us to form very accurate or complete arrangements of them on thefe principles; yet it is certainly an object of importance to the ftudent of mineralogy to know the prefent ftate of chemical fcience refpecting thefe fubftances, and what advantage the mineralogift can derive from it in arranging them.

Of all the philofophers who, fince Cronftedt, have attempted to arrange earths and ftones by their chemical properties, Bucquet, Bergman, and Kirwan, have been the moft fuccefsful, and have given the moft complete fyftems. As each of thefe gentlemen has followed a peculiar mode of arrangement, and as each of their methods poffeffes fome undeniable advantages, we fhall here lay before our readers fucceffive views of the three fyftems, and fhall at the fame time point out their feveral defects.

§ I. *Of the Chemical Division of Earths and Stones propofed by* BUCQUET.

BUCQUET, after many laborious refearches with a view to this objeƈt, at length formed, a little before his death, a fyftem of earths and ftones, on the compound principle of their chemical properties and their exterior charaƈteriftics, as obferved by naturalifts, which he had refolved to follow in his future courfes of leƈtures. In repeated converfations with him during the lingering illnefs which ended in his death, I obtained a full account of that method; which was communicated to the public in the firft edition of this work. I fhall now again give it as it then appeared, only adding a few notes, to take notice of the improvements which this branch of the fcience has received fince the year 1779.

According to Bucquet, earths and ftones fhould be arranged under three divifions : the firft comprehending fimple earths and ftones; the fecond, compound earths and ftones; and the third, mixtures of earths and ftone.

Simple earths and ftones, in a ftate of purity, are infipid, dry, hard, infoluble, and infufible. Whenever any of them appear to poffefs thefe properties in a lefs perfeƈt degree, more efpecially when any of them appear fufceptible of fufion, they are to be confidered as not pure, but alloyed by the mixture of fome extraneous matter. Such as are pure, admit not of decompofition by chemical analyfis; but the number of pure ftones is much more fcanty than Bucquet thought it.

- Compounds earths and ftones are to be regarded as combinations of the fimple earths with faline or metallic fubftances. Thefe combinations have been effected by the operation of fire or water in the great laboratory of nature. Their chemical charaƈteriſtics are, to melt eafily, to fuffer vitrification from the aƈtion of fire, and to be feparable into feveral fimple fubftances by the aƈtion of folvents, more efpecially by the aƈtion of acids.

' Mixed earths and ftones are eafily diftinguifhed by infpeƈtion. They feem to be formed by the irregular aggregation of feveral earths and ftones, both fimple and compound. To analyfe them, the feveral different matters of the irregular aggregate muft be divided and examined each by itfelf. Their peculiar natures may be then certainly determined by chemical experiments.

D I V I S I O N I.

Simple Earths and Stones.

THESE are divided into four orders.

ORDER I.   VITREOUS STONES.

THESE are extremely hard, and perfeƈtly tranfparent; of a vitreous fraƈture ; give fire with fteel ; and fuffer no alteration in tranfparency or hardnefs from the aƈtion of heat

This firft order contains two genera; rock-cryftal and vitreous precious ftones.

Genus I. *Rock-Cryſtal.*

ROCK-CRYSTAL exhibits all the properties of vitreous ſtones in the moſt eminent degree. Its fracture, which ſ ſimilar to that of glaſs, diſtinguiſhes it from the foloowing genus.

It may be ſubdivided into ſpecies.

1. *By the Property of Form.*

Species.

1. Inſulated hexahædral cryſtals, which two hexahædral pyramids. The Abbé Rochon has obſerved, that theſe produce a double refraction.

2. Hexahædral cryſtals, united in groups, with one or two points.

3. Tetrahædral, duodecahædral, flattened, &c. cryſtals. Thoſe of which the facets are varied and irregular are always hexahædral.

4. Rock-cryſtal in maſſes, from Madagaſcar. It produces only a ſingle refraction.

2. *By the Property of Colour.*

5. Reddiſh rock-cryſtal.
6. Smoky cryſtals.
7. Black cryſtals.
8. Yellow cryſtals.
9. Blue cryſtals.
10. Green cryſtals.

3. *By accidental Circumſtances.*

Species.

11. Hollow rock-cryſtal.

12. Containing water.

13. One cryftal inclofed within another (emboités).

14. Rounded ; pebbles from the Rhine.

15. Incrufted with metallic calces.

16. In gæodes.

17. Containing amianthus.

18. Containing fchorl.

19. Incrufted with pyrites.

Their formation by water is proved,

1. By their tranfparency.

2. By the form of fmall cryftals.

3. By the inclofure of one cryftal in another.

4. By their inclofing fubftances alterable by fire.

They are cut and polifhed into vafes and toys.

Genus II. *Vitreous Precious Stones.*

THE precious ftones which we rank under this ge-
nus, have all the properties which charaçterife rock-
cryftal, and more efpecially its inalterability by fire.
Though this may feem extraordinary, fince Berg-
man informs us, that he found thefe ftones to be
compofitions of feveral different matters ; yet in their
hardnefs, their tranfparency, and the manner in
which they are affeçted by fire, they differ but little
from rock-cryftal ; they are, however, inferior in hard-
nefs, their colour is not fo clear and lively, and their
fraçture is lamellated. The differences among preci-
ous ftones, particularly with regard to the manner in
which they are affeçted by fire, induced Bucquet to fe-

parate

parate them, and to arrange them among thofe of the orders of ftones to which they have the neareft refemblance.

The four precious ftones which we diftinguifh by the denomination of vitreous, are,

Species.

    1. The oriental topaz.
    2. The hyacinth.
    3. The oriental fapphire.
    4. The amethyft.

M. Daubenton has always confidered this laft as a quartz cryftal.

ORDER II.   QUARTZOSE STONES.

THESE are not fo hard or tranfparent as the former; their fraɛ̃ure is vitreous ; and they give fire with fteel. Heat deprives them of hardnefs and tranfparency, and reduces them to a white opaque earth *.   Under this order we arrange four genera.

Genus I.   *Quartz.*

It poffeffes all the above charaɛ̃eriftics.

Species.

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* It was on account of its being liable to alteration by fire, that Bucquet diftinguifhed quartz from rock-cryftal, and arranged it under a particular genus.   He likewife obferved, that quartz dipped in water, after having been for feveral times fucceffively heated red hot, communicated to that fluid a degree of acidity.   Future experiments will determine the certainty of this faɛ̃—F.

3

Species.

1. Tranſparent quartz, cryſtalliſed in hexagonal
   pyramids; its priſms either not obſervable,
   or at leaſt very ſhort.
2. Tranſparent quartz in maſſes.
3. Opaque or lacteous quartz.
4. Greaſy quartz.
5. Carious quartz.
6. Green, blue, or violet quartz; priſm of ame-
   thyſt.
7. Yellow quartz, of a lamellated fracture.

Topaz $\left\{\begin{array}{l}\text{Saxon.}\\\text{Braſilian.}\end{array}\right.$

Theſe topazes poſſeſs all the characteriſtics of quartz

Genus II. *Flint, Agate.*

FLINTS and agates are ſmall round maſſes, generally
opaque, ſometimes ſemi-tranſparent, either hollow or
ſolid, of various colours, and diſpoſed in ſtrata,—in
chalk, as is the caſe with flints; or in clay, as agates.
Their fracture is ſometimes ſcaly.

Species.

1. Grey flint.
2. Yellow flint.
3. Red flint.
4. Corneous flint; gun-flint.
5. Brown Egyptian flint.
6. Tranſparent clouded flint; German agate.
7. Red agate; male cornelian.
8. Pale red agate; female cornelian.
9. Brown or yellow agate; ſardonyx.

10. Agate

ies.

10. Agate-onyx, in concentric laminæ.

11. Agate-Cameo, in horizontal layers; but the appearance of the laminæ, and their difpofi-tion with regard to the figure of the ftone, depends in a great meafure on the manner in which it is cut.

12. Figured agates.
{ Dendrites; herborized agates *.
Anthropomorphites.
Zoomorphites.
Uranomorphites.

13. Agate, apparently mouldy; marked with fmall green points, generally owing to moffes.

14. Agate of four colours; elementary.

15. Grey agate; grey chalcedony.

16. White, lacteous, or chalcedony agate.
{ in layers.
in ftalactites.
round, cacholong.

17. White agate, with a wavy re-flection of the light.
{ Lapidaries agate, *chatoy-ant* luftre.
Cat's eye.
Oculus mundi, or hydro-phanes.
Opal.
Girafol.

18. Brown agate, with brilliant gold-coloured points. Avanturine.

19. Oriental agate.

20. Agate containing water (Enhydre).

The formation of quartz, agates, and flints, is owing) water, as is proved,

1. By

* M. Daubenton has fhown, in a memoir read to the Academy, ist herborifed ftones contain very fine moffes, or fmall grains of black on ore.—*F.*

1. By their form.
2. By their layers.
3. By their moffes.
4. By their containing water.
5. By the organized matters mixed with them, as
    in the moffy or mouldy agates.

This alfo appears from the circumftances and pro-
perties of the gæodes. Thefe are ftone boxes, filled
with cryftals : they contain filex and quartz arranged
in concentric layers.

Genus III.   *Organic Matters converted into Silex, or
Agate.*

THESE are diftinguifhed from the other genera of
this order, by poffeffing the characteriftic properties of
quartzofe ftones under an organic form *.

Species.

1. Wood petrified, but ftill fibrous, and fufcep-
    tible of polifh.
2. Wood, the texture of which indicates its par-
    ticular kind.   Fir.
3. Sea-urchins and madrepores converted into
    filex.
4. Shells converted into agate.
5. Carpolites : thefe have been miftaken for pe-
                                                      trified

* It would perhaps be a much more natural mode of divifion, to
arrange under a diftinct clafs, all fuch animal and vegetable fubftan-
ces as have fuffered alteration from lying under ground.   The name of
that clafs might be foffils, and it might be placed at the end of the or-
ganic kingdoms.—F.

trified fruits; they are properly small *ludi-belmontii* silicified.

6. Entrochites.

7. Lapis frumentarius siliceus.

This last stone gives fire with steel, but does not effervesce with acids. It seems to be formed by an assemblage of cornua ammonis divided perpendicularly to their volutes.

There are two opinions concerning petrifaction. Some think that organized bodies are entirely transmuted into stone: others are of opinion, that the void spaces formed by animal substances in soft earths, and the interstices in the fibrous texture of vegetables, are gradually filled up by an accumulation of earthy matter. But we can pretend to no certain knowledge of the cause of this phenomenon. Vegetable matters are observed to become almost always quartzose, and scarce ever calcareous; while animal substances, on the contrary, become generally calcareous, and seldom quartzose [*]. From this fact we may almost conclude, that no real petrifaction takes place, and that organized bodies are not converted into stone: For, 1. Shell-fish and madrepores only lose their mucilage or animal gluten, by putrefaction, and are reduced to calcareous skeletons, which existed during the life of the animals: 2. What is said to be petrified wood, is nothing else

than

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[*] Since the discovery of the fluoric acid gas, which possesses the property of decomposing quartzose earth, some naturalists have conjectured, that petrifaction may be produced in a similar manner. But this is to be regarded as mere conjecture, till such time as it be shown that there exists in the interior parts of the earth an acid which maintains quartzose earth *in a* state of solution,—F.

than an accumulation of vitrifiable earth in moulds formed by putrefied vegetables. As the fibres of the vegetable body are gradually deſtroyed by putrefaction, a quantity of quartzoſe earth is depoſited by the water in the ſpace which they occupied : a quartzoſe ſtone is thus formed of the very figure and texture of the vegetable body, but not a particle of this ſubſtance enters into its compoſition.

<h2 align="center">Genus IV. <i>Jaſper.</i></h2>

JASPER poſſeſſes all the characteriſtics of quartzoſe ſtones. It is infuſible, but loſes its aggregation by fire: it is extremely hard, opaque, and variegated with divers colours ; its facture is duſky and vitreous. It is not often found arranged in beds ; it generally compoſes conſiderable maſſes or veins in rocks : It is alſo found in ſmall round lumps. Moſt ſpecimens of jaſper that we have ſeen, are mixtures of quartz and chalcedony. It ſometimes contains calcareous ſpar.

Naturaliſts have divided jaſper into a great many ſpecies. Theſe may be reduced to the following.

Species.

    1. White jaſper.
    2. Grey.
    3. Yellow.
    4. Red.
    5. Brown.
    6. Green.
    7. Veined.
    8. Spotted.
    9. Green, with red points : bloody jaſper.
   10. Flowered.

            L   Jaſper

Jasper is used for making toys, particularly cups and
ls. There are many antique engravings on stones of
s kind.

Genus V.   *Grit, or Free-stone.*

GRIT-STONE is opaque, of a granulated fracture,
iob softer than quartz or flint ; it is found in large
sses, of various degrees of hardness, and sometimes
er sometimes coarser grained.

ies.
1. Grit Cryſtallifed in rhombi.   M. de Laſſone has
    ſhown that theſe owe their form to the chalk
    incorporated with them *.
2. Grit in the form of cauliflowers.
3. In ſtalagmites.
4. White.
5. Grey.
6. Red.
7. Black, or Brown.
8. Veined.
9. Figured, or herborifed.
10. Grit, of which the aggregation is deſtroyed;
    ſand.

Sand appears under the following varieties :

ieties.
1. Quick-ſand.
2. Angular ſand.
3. Sand rounded by the action of water.

* Memoirs of the Academy of Sciences for the year 1777—F.

    4. Pure white ſand.
    5. Micaceous ſand ; glarea.
    6. Yellowiſh, argillaceous ; founder's ſand.
    7. Ferruginous ſand ; yellow.
    8. ――――――― black.
    9. Blue ſand ; fro·n copper.
  10. Violet ſand ; from tin.
  11. Auriferous ſand.

ORDER III. ARGILLACEOUS EARTHS *and* STONES.

THESE are greaſy ; clammy, or pliant ; ſtick to the tongue ; foliated ; frequently coloured ; and diſpoſed in large maſſes, and in layers.

Their force of aggregation is leſs than that of quartzoſe ſtones ; but they have a greater tendency to combination, and are therefore often altered. Heat contracts and hardens them, ſo as to give them the appearance of quartzoſe ſtones, and to cauſe them to give fire with ſteel as well as thoſe. Water reduces them to a paſte, divides, and purifies them ; they abſorb water, and retain it with ſuch force of combination, that they cannot bｅ again totally deprived of it.

Part of the ſubſtance of theſe ſtones combines with acids. Some chemiſts have taken clay to be nothing but ſiliceous earth altered by the ſulphuric acid ; but that opinion has not yet been fully proved.

Many naturaliſts have entertained an opinion, that vitrifiable earths, after being long expoſed to the agency of water, air, and heat, are ſeparated and reduced into fine ſoft particles, capable of combination with water, and thus paſs into the ſtate of clay. This theory

I   being

; founded on fome accurate obfervatiohs, merits
refpect than the former : But the evidence of nei.
amounts to demonftration.

efe two properties of mixing with water fo as to
ofe a ductile pafte, and again becoming hard by
tion of fire, render clay fit for being wrought
tiles, bricks, pottery, delft-ware, and porcelain :
n account of thefe makes a part of the hiftory of
ind of earths.

turalifts have defcribed a great many kinds of ftones
onging to this order; but they have confouded a-
them many falfe clays and compound ftones;
are, of the laft, ferpentine, zeolite, trapp, &c.

e name of *clay* properly belongs to none but fuch
as are hardened by fire, are diluted in water,
ombine with the fulphuric acid to form alum.

cquer having examined a great many of them,
none abfolutely pure *. Many of them owe
colour and fufibility to their being mixtures of
is combuftible and metallic fubftances.

:quet divided them into four genera.

Genus I. *Soft Ductile Clays.*

ESE, when dug from the bed or quarry, may be
ed; but they become dry in the open air.

. White clay; pipe clay.
. Sandy clay.
. Clammy blackifh clay; for white pottery.
. Clay, with a mixture of mica, kaolin; partly
   fufible; for porcelain,

Q 2   5. Me.

* *Academy of Sciences,* 1758—F.

Species.

5. Metallic clay, fuſible ; terra figillata ; Arme-
nian bole

6. Pyritous clay ; fuſible ; blue, green, marble;
uſed in common pottery.

Genus II. *Dry, Friable Clays ; Clay of Tripoli.*

ALL thoſe clays which Bucquet ranked among the
tripolis, are dry in the interior parts of the earth. They
are all found in beds or layers, often very thin, and ar-
ranged one above another.   All of them crumble down
into duſt under the finger, and abſorb water readily;
they likewiſe ſtick to the tongue.

Species.

1. Dry, grey, foliated clay ; fullers earth.

2. Red tripoli.   Some people take this to be a
volcanic product.

3. Grey tripoli.

4. Black tripoli.

5. Rotten ſtones of an olive grey colour.

Genus III. *Schiſtus.*

SCHISTI are foliated ſtones which ſplit readily into
plates : they are a mixed fuſible ſubſtance ; they are
placed in huge maſſes in the bowels of the earth, and
always in an oblique direction.   Almoſt all quarries of
ſchiſti exhibit on their exterior ſurface, and in the up-
permoſt layers, impreſſions of plants of the ruſh and fern
kinds, &c. of ſhells, fiſhes, or inſects, &c.

Species

Species.

1. Black fchiftus, tender; ampelite.
2. Fiffile fchiftus; flate.
3. Black, hard fchiftus; writing flate.
4. Red, brown fchiftus, &c.
5. Schiftus marked with impreffions of vegetable or animal bodies.
6. Very hard fchiftus, naxian ftone, ufed for whetting razors.

Genus IV. *Feldt-Spar.*

IT exifts in the form of rhomboidal plates; its fracture is fpathofe, and it gives fire with fteel : It is for this reafon called *fcintillating fpar*. Though harder than fchiftus, it is fufible. Bucquet fuppofed it to be an argillaceous ftone, coloured by a mixture of iron. M. Monnet confiders it as a compound of quartz, clay, magnefia, and a fmall portion of calcareous earth. Its being but little known is the caufe of this diverfity of opinions concerning its nature. A more accurate examination muft determine its true character *.

Q 3   Species

* Father Pini, an Italian naturalift, was the firft who defcribed ryftallifed feldt-fpar. Since his difcovery, it has been found in many laces in France. Very regular feldt fpar cryftals are found at Roanne n Forez. I have given a minute defcription of that which is found n the Alençon granites, and which is one of the moft regular and eautiful with which I am acquainted, in my *Memoires de Chemie.*—F.

Species.

  1. Prifmatic feldt-fpar *.

  2. White feldt-fpar †.

  3. Red feldt-fpar.

  4. Green feldt-fpar.

  5. Blue feldt-fpar.

ORDER IV. FALSE CLAYS.

THESE refemble clays only by having a foliated tex.
ture, and greafy appearance ; fome of them indeed har.
den by fire.

They differ from clay, as not being fit for compo·
fing a pafte with water, and as being moft of them
fufible in fire. They combine with the fulphuric acid
to compofe a falt in the form of needles, which fuffers
no alteration from air, but is foluble in four or five
parts of water, and does not fwell in fire ; in a word, is
not alum. Bucquet, who had examined a great many
of thefe ftones, gave thefe as their charaçteriftics : but
as they are very little known, they may ftill be ranked
near the clays ‡.

<div align="right">Genus</div>

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 * M. Daubenton ranks this among the fcintillating ftones. It is di-
ftinguifhed by three charaçteriftics from every other fpecies of ftones ;
its texture is fpathofe ; it yields a changing or *chatoyant* luftre ; and it
gives fire with fteel. With thefe charaçteriftics, this genus muft con-
tain more fpecies than Bucquet afcribed to it. M. Daubenton includ-
ed under it the fifh's eye, the avanturine, and the labradore ftone.—F.

 † It has been afcertained by experiment, that 100 parts of white
feldt-fpar, contain about 67 filex, 14 alumine, 11 barytes, and 8
magnefia.—H.

 ‡ The Abbé Mongez, in his Introduçtion to Bergman's Sciagra-
phy, obferves, that thefe ftones might be with more propriety named
magnefian ftones. I fhould willingly agree to ufe that name ; but I be-
lieve a number of experiments are neceffary before we can receive it as
expreffive of their nature.—F.

Genus I. *Lapides Ollares,* hard.

Their texture can fcarce be called foliated; their ap-
arance is greafy; and they are fufceptible but of an
lifferent polifh.

cies.

1. Grey, Swedifh lapis ollaris.
2. Greenifh lapis ollaris; Swedifh colubrine.
3. Yellowifh lapis ollaris; Chinefe foap-ftone.
4. Bright green lapis ollaris; jade. Bucquet
    thought the nephritic and Otaheitean ftones
    to be varieties of the jade. The jade is very
    hard, and gives fire with fteel. Bucquet ap-
    pears to have followed Pott in placing it a-
    mong the lapides ollares.
5. Dirty green lapis ollaris; colubrine.
6. Serpentine. A ftone of a deep green, or ra-
    ther blackifh colour, with black fpots or
    veins, like a ferpent's fkin. On account
    of its appearance, we have placed it at the
    end of the lapides ollares; it feems to be a
    compound.

nus II. *Soft Lapides Ollares; Steatites,* or *Smec-
titcs.*

These are more of the nature of foap than the fore-
ng genus. They may be eafily cut; they frothe
h water; and fome of them have externally a ftri-
ig refemblance to foap.

Species,

Species.

1. White, compact ſteatites; Briançon chalk.
2. Bright Briançon chalk; the druggiſts Venice-talc.
3. White, Norwegian ſteatites.
4. Red marbled Norwegian ſteatites.
5. Reddiſh Norwegian ſteatites.
6. Green compact ſteatites from Norway.
7. Green and red ſteatites from Norway.
8. Green, foliated; ſoft colubrine of Norway.
9. Black ſteatites; uſed by ſtone-cutters.
10. Sparkling grey ſteatites; plumbago, molybde-na, and very improperly black lead. Plum-bago being reduced to powder, and wrought into a paſte with a mixture of iſinglaſs, is in-cloſed in ſmall cylinders, which are cut to a point at one end, and uſed as pencils or cray-ons *,

Genus

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* Since the death of Bucquet and the firſt edition of this work Meſſrs. Scheele, Gahn, and Hielm, have very ſuccefsfully inveſtigated the nature of plumbago; they have found it to be a carbure of iron. We ſhall give its hiſtory after that of ſulphur. The ſame chemiſts, more eſpecially M. Scheele, have made a very proper diſtinction be-tween plumbago and molybdena, which former naturaliſts had always confounded together. M. Scheele conſiders molybdena as a compound of ſulphur with a certain acid, to which he gives the name of the molyb-denic. *(See the hiſtory of metals.)* It is plumbago which is uſed for pen-cils.— F.

In England, the plumbago uſed for pencils is not ground to powder and mixed with iſinglaſs; but cut into long ſlender pieces and inclo-ſed in wood. Thoſe deſcribed by the author are an inferior kind.—H.

Genus III. *Talc.*

It confifts of polifhed glittering plates, difpofed one over another, and of a gelatinous tranfparency. Thefe laminæ or plates are fometimes cryftallifed in an hexagonal form, or in fections of fix-fided prifms. A ftrong fire melts it into a coloured glafs.

Species.

1. Talc in large tranfparent plates; Mufcovy glafs.
2. Talc in very fmall filvered fpangles.
3. Talc in very fmall golden fpangles. Thefe two kinds are ufed to dry writing, under the name of *gold* or *filver powder.*
4. Talc worn into the form of pebbles.
5. Talc in black fpangles.
6. Talc in mixed brilliant fpangles.

Genus IV. *Amianthus, Afbeftos.*

The ftones of this genus confift of fibres or threads difpofed parallel to one another, or interwoven like the texture of a web. Thefe threads are fometimes ftiff, fometimes flexible; and they differ from one another in colour, length, and thicknefs. The ancients fpun them, and made of them a kind of cloth, to which they gave the name of *incombuftible linen,* in which they burnt the bodies of the dead, in order to preferve their afhes, &c.

Amianthus melts, in a ftrong fire, into an opaque coloured glafs.

Species

Species.

1. Hard grey aſbeſtos, with parallel threads; ligneous aſbeſtos.
2. Hard greeṅ aſbeſtos, with parallel threads.
3. Hard green aſbeſtos; its threads in bundles.
4. Aſbeſtos, with diverging fibres.
5. Hard aſbeſtos, with ſoft fibres.
6. Hard amianthus, with parallel greeniſh fibres.
7. Hard amianthus, with parallel white fibres.
8. Amianthus in bright white bundles.
9. Amianthus in hard yellowiſh bundles.
10. White flexible amianthus.
11. Grey amianthus.
12. Mountain fleſh.
13. Mountain leather.
14. Mountain cork.

D I V I S I O N   II.

Compound Earths and Stones.

THESE cannot be diſtinguiſhed by ocular obſervation from thoſe of the former diviſion. As to the nature of their compoſition, they are formed of an homogeneous matter, almoſt always coloured, generally opaque, but ſometimes tranſparent; moſt of them are regularly cryſtallized. They are diſtinguiſhed into genera by form and colour. They are all very fuſible, and afford glaſs of various kinds. Their fracture is ſometimes vitreous, ſometimes ſcaly. In theſe ſubſtances nature has combined together earths, ſalts, and metals.

<div align="right">Bucquet</div>

Bucquet divided thefe ftones into two orders: Un-ler the firft he comprehended earths and ftones com->ounded with water, which he characterifed as pro-lucts of that element. This order again he divided nto two genera, namely, ochres and zeolite. Under :he fecond order he reckoned fchorl, macles, trap, a-:ure ftone, fufible precious ftones, volcanic cryftals, :olcanic glafs, and pumice ftones : thefe eight kinds of tone he confidered as formed by the action of fire. We have undertaken to give an account of the ideas of that :elebrated chemift concerning the nature and claffifica-tion of ftones; but as the diftinction between thefe two orders is not eftablifhed by a fufficient number of conclufive facts, and as M. Bucquet himfelf offered them only as hints, we fhall here give the hiftory of thefe genera fucceffively, without dividing them into orders.

Genus I. *Ochres.*

OCHRES are lefe eafily diluted in water than clays; they are friable and foil the fingers; they are co-loured by metallic matters, generally by iron. When expofed to a ftrong fire, they affume a deeper co-lour: violent heat melts them. They are ufed in paint-ing.

Species.

1. Yellow ochre.
2. Red ochre, blood coloured.
3. Green ochre; Verona earth.
4. Brown ochre; Umber earth.

Genus

Genus II. *Zeolite.*

THE zeolite, firft defcribed by Cronftedt, is a ftone compofed of needles diverging from a common centre. It neither gives fire with fteel nor effervefces with acids: When expofed to fire it fwells and produces a white opaque glafs refembling enamel.   By diftilling it in a retort, a confiderable quantity of water is obtained. The refidue, according to Bergman, confifts of filiceous, aluminous, and calcareous earth.   Bucquet, who analyfed it, mentioned his having found in it a very little filiceous earth, and a particular kind of earth neither aluminous nor calcareous; which with the fulphuric acid afforded a falt cryftallized in fmall fhining plates, refembling the boracic acid, and to which he thought proper to give the name of *zeolitous earth*.   Thefe two earths are cryftallifed together by the help of water, which forms more than an eighth part of the compofition : for, from an ounce of white zeolite, from the ifland of Ferro, M. Bucquet obtained a dram and an half of water *.   The property of compofing a jelly with various acids is not peculiar to it; azure ftone, tin, and feveral iron ores, &c. are capable of a fimilar compofition †.   Its origin and formation are unknown; abundance of it is found among the produ&ts of volcanoes.

* See *les Memoires de Savans etrangers*, *Tome IX. p.* 576.

† M. Pelletier, apothecary, a difciple of M. d'Arcet, has given in the *Journal de Phyfique* (1782, vol. XX. page 420.) a memoir on the analyfis of the zeolite of Ferro.   He has found, by the moft accurate experiments, that 100 grains of this ftone contain 20 grains of aluminous, 8 grains of calcareous, and 50 of filiceous earth, and 22 grains of water.   Confult that memoir.—F.

noes. There is great plenty of in the ifle of Ferro. We are aquainted only with five kinds of it.

Species.

     1. White zeolite, in tranfparent fafces.
     2. White zeolite, in compact fafces.
     3. Red zeolite.
     4. Green zeolite.
     5. Blue zeolite.

Neither the red, the green, nor the blue, has yet been examined.

Genus III. *Schorls.*

SCHORL is a dark-coloured ftone, generally violet, black, or green, very feldom white, fufficiently brittle, and capable of giving fire with fteel. It melts eafily into a black opaque glafs : it is, according to Bucquet, a combination of iron and aluminous earth. Bubbles have been found in the interior part of fchorls, fimilar to thofe in the flags of glafs-houfes.

Its origin is not very well known. Some people think it a volcanic product, becaufe it is often found in places which have felt the ravages of fire ; but it is like-wife found among matters which have been long ex-pofed to the action of water.

Species.

     1. Violet fchorl, in cryftals.
     2. Violet fchorl in fibrous maffes.
     3. Black fchorl, in prifms of 4, 6, 8, or 9 fides,

with

with pyramids of 2, 3, or 4 faces, like the
violet fchorl.

4. Black fchorl, in maſſes.
5. Green fchorl, in lamellated maſſes.
6. White fchorl, fomewhat blueiſh.
7. Electric fchorl, of a yellowiſh red, tourmaline.

Genus IV. *Macles.*

UNDER this name we comprehend a genus of ſtones, of
a priſmatic form, opaque, dirty-coloured, and generally
of a regular figure. By analyſing them M. Bucquet found
them to be of a nature nearly reſembling that of fchorls,
namely, a compound of iron and aluminous earth.

Species.

1. Tetrahædral macle, the ſection of which exhi-
   bits the figure of the croſs.   It is found in a
   kind of hard deep blue ſchiſtus of Brittany, to
   which it adheres ſtrongly : it is very brittle,
   and when broken exhibits on its tranſverſe
   ſection two blueiſh lines, cutting each other
   in the form of a croſs. Sometimes the middle
   of the priſm appears to be full of a matter re-
   ſembling that of a gangue.
2. Stones of the croſs; hexahædral priſms, articu-
   lated and croſſed in the middle like the arms
   of a croſs; theſe are found in the leaves of
   yellow mica ; the two arms never croſs each
   other at right angles.

Genus

Genus V. *Trap.*

TRAP is an hard ftone fine grained, of a foliated fracture, and angular, like the fteps of a ladder. Its colour is a deep green, approaching to black, often inclining to the colour of ochre ; it is very ponderous, and gives fire with fteel. It melts into a blackifh glafs, and is always covered with a kind of cruft fofter than itfelf. It is a compound of aluminous earth and iron : According to Bucquet iron exifts in it, in the proportion of twenty-five pounds to the quintal, fo that it might be confidered as an iron-ore. M. Daubenton thinks it a fchiftus containing quartz in fand. There is only one kind of trap known,—that which we have defcribed.

Genus IV. *Azure Stone; Lapis Lazuli.*

THIS ftone is claffed along with the preceding genera, on account of its colour, the finenefs of its grain, and the quantity of iron which, from an analyfis, it appears to contain.

Species.

1. Oriental azure ftone.
2. Azure ftone, of a pale blue, and often purplifh.
3. Armenian ftone, clouded with white and pale blue.

The azure blue ufed in painting, which is one of the moft fixed and permanent colours known, is a preparation of this ftone.

Genus

Genus VII.   *Fusible Crystal Gems.*

M. Bucquet, in consequence of observing the diﬀ-
ferences of the various kinds of gems, or precious stones
as to chemical properties, was induced to arrange them
separately under thofe diviſions and orders to which
they ſeemed moſt properly to belong.   Thofe which
we are going to introduce in this place are evidently
compounds.   Bergman found them to conſiſt of various
ſubſtances, ſuch as ſiliceous and aluminous earth,
lime, and iron; all of them are fuſible, and compoſed
of laminæ.   Their fracture is lamellated.

Species.

    1. Aqua-marina.
    2. Emerald.
    3. Cryſolite.
    4. Ruby.
    5. Vermilion, or Bohemian garnet.
    6. Garnet.

Genus VIII.   *Volcanic Cryſtals.*

Under this genus Bucquet comprehended all ſuch
ſtones as are of a regular form, tranſparent, coloured,
and ſimilar to cryſtal gems, but poſſeſs not the hardneſs
or brilliancy of theſe laſt.   They are found in cavities
lined with ſmall ſparkling particles of the ſame nature,
agglutinated together.   They are met with in the
neighbourhood of volcanoes.   We admit three ſpecies
of them.

scies.

I. Volcanic chryfolite; polyhædral cryftals of a golden green.
2. Volcanic hyacinth, polyhædral cryftals of an orange yellow.
3. Volcanic garnets. Thefe ftrongly refemble fingle garnets; but they are irregular, and, as well as the two foregoing fpecies, fcattered among brilliant lavas.

Genus IX. *Pumice Stónes.*

MOST pumice-ftones appear to be a collection of vi-ous threads wound up together, nearly like yarn on a ie. The pumice-ftone is really a combination of va-us fubftances which have been reduced to fufion by : volcanic heat.

Pumice-ftones may be divided into four fpecies; each which has many varieties.

cies.

1. White fibrous pumice-ftone.
2. Coloured fibrous pumice-ftone.
3. Light cellular pumice-ftone.
4. Compact cellular pumice-ftone.

Genus X. *Volcanic Glafs.*

THE glafs melted and difcharged by Volcanoes is a cture of earthy and faline matters, coloured with

iron or ſome other metallic ſubſtance.   It is actually a
natural chemical combination effected in the dry way.

Species.

    1. Greeniſh cellular glaſs.
    2. Blackiſh cellular glaſs,   or in agglutinated
       threads.
    3. Black glaſs, very fine and tranſparent; Ice-
       land agate; lapis obſidianus of the ancients.

D I V I S I O N   III.

Mixed Earths and Stones.

THE characteriſtics of the ſtones of this diviſion are
eaſily diſtinguiſhed.   We can diſcover merely by in-
ſpection, of what different matters they conſiſt; and
the more readily if we compare them with the ſtones
of the two foregoing diviſions.   We formerly obſer-
ved, that, in order to analize them, it is firſt neceſſary
to divide the various ſubſtances with an hammer ; after
this operation is performed, they are found to conſiſt of
ſimple united with compound ſtones.   If theſe mixed
ſtones be expoſed unbroken to the action of fire, they
will melt with more or leſs facility into a party-colour-
ed glaſs, the nature and colours of which will be ac-
cording to thoſe of the matters of which it is com-
poſed.

Theſe ſtones appear to have been formed by the u-
nion of the ſeveral ſubſtances of which they conſiſt, ef-
fected either by fire or water.   On account of this cir-
cumſtance, Bucquet ſubdivided this third diviſion into

two

two orders, as well as the foregoing. His firſt order comprehends mixed ſtones formed by water: the ſecond, ſuch as owe their compoſition to fire. As this ſubdiviſion is authoriſed by many more faċts than that of the ſecond diviſion, we ſhall follow it with more confidence.

ORDER I. EARTHS *and* STONES *Mixed by* WATER.

Genus I. *Petro-filex*, or *Rockſtone.*

BY this name naturaliſts denote a ſtone of an intermediate hardneſs between ſoft ſtones and filex. M. Daubenton ranks it among the vitreous ſtones, becauſe it ſcintillates with ſteel, and its fraċture is vitreous, though ſometimes rather ſcaly. Petro-filex has a kind of faint or half tranſparency like wax. It is duſky and deſtitute of brilliancy, and has even ſomewhat of the appearance of tallow; it is fine grained and very compaċt; it is found in large maſſes: it ſometimes diſplays layers variouſly ſhaded, diſpoſed one over another. The chemical charaċteriſtic by which M. Bucquet diſtinguiſhed it, was its diſpoſition to melt by fire into an opaque glaſs. It is far from being ſo eaſily diſcoverable to be a mixture as the following genera; it ſeems to poſſeſs the charaċteriſtics of compound ſtones *; and

R 2   for

* I muſt here obſerve, that theſe charaċteriſtics of ſtones, derived from the manner in which they are affeċted by fire, are founded on experiments made by M. Bucquet, in conjunċtion with the Duke de Rochefoucault, in an excellent furnace for fuſion, conſtruċted on purpoſe in the laboratory in which that illuſtrious cultivator of chemiſtry

for this reafon we rank it at the head of the third divi-
fion : it forms a kind of of intermediate ftep between
this and the foregoing.

The form of its layers, the matters which they often
contain, and ftill more the maffes in which it is accumu-
lated in the bowels of the earth, fhow plainly that it owes
its origin to water.

Species.

1. Grey petro-filex.
2. Reddifh.
3. Greenifh.
4 Brown.
4. Black.
6. Spotted.
7. Veined.

Genus II.   *Pudding-Stone.*

PUDDING-STONE is a mixture of flints united by a
cement of a different nature.   That cement is either
gritty or argillaceous, or ochreous; fometimes it is hard,
and refembles filex.

Its formation is by no means equivocal; it is owing
to water.   Thefe ftones are always found either on the
fea-fhore, or in places which have been once covered
with water, and afterwards left dry.

Species

miftry profecutes fo many refearches for the improvement of the
fcience.   I have re-examined moft of the refults of thefe experiments,
which it is to be hoped will be one day communicated to the public:
they will confirm the fine feries of experiments made by M. D'Arcet;
and will add to them a number of facts, ferving to fupport Bucquet's
arrangement of ftones.

Species.

1. Sandy pudding-ftone *.
2. Ochrous.
3. Argillaceous.
4. Siliceous.
5. Agatified ; fufceptible of the fineft polifh.

Genus III. *Granite.*

GRANITE is formed by the union of fmaller or larger fragments of three different ftony matters. Thefe are quartz, feldt fpar, and mica.

On account of the quartz and feldt-fpar which it contains, it gives fire with fteel: its fracture is irregular and coarfe-grained : it is fufible, but in various degrees, according as the three component matters are proportioned in the compofition. It is fufceptible of a finer or an inferior polifh according to the finenefs of its grain and the hardnefs of its principles. Some fpecies of it fuffer alteration, and wafte away by the action of the external air. This laft phenomenon enables us to diftinguifh ancient from modern granite. It has been fubdivided into many fpecies : But we fhall reduce them all to the following †.

R 3   Species.

* I have obferved fome of thefe in the very act of forming ; while they were, yet, foft and flexible, but, tough, and fufficiently cohefive. —H.

† The natural hiftory of granites has been much ftudied by modern naturalifts. M. Sauffure, in his *Voyage des Alpes*, has communicated a number of new and important facts un this head. Granites are not invariably formed of a mixture of thofe three ftones. Some of them, inftead of mica, contain fchorl ; others contain both fchorl and at the fame time. A mixture of quartz and feldt-fpar, with

3

Species
 1. White granite.
 2. Grey.
 3. Red.
 4. Brown.
 5. Green.
 6. Black.
 ,7. Dirty and friable granite, having fuffered alte-
   ration by the action of fire.

Genus IV. *Porphyry.*

PORPHYRY is a ftone fpeckled with fpots on a ground
of red, or fome other colour. It produces abundance
of fparks when ftruck with fteel.

It differs from granite in being harder and fufceptible
of a much brighter polifh : it feems to confift of feldt-
fpar and fchorl, united by a quartzofe cement.

The pafte which conftitutes the ground of porphyry
is of a very fine clofe grain ; the other fragments uni-
ted in it are generally much fmaller than thofe of gra-
nite. This ftone is fufible into a coloured glafs. All
the fpecies of porphyry may be reduced to the follow-
ing feven.

Species.
 1. Red porphyry, with large fpots.
 2. Red porphyry, with fmall fpots.
 3. Green porphyry, with large fpots.
 4. Green porphyry, with fmall fpots.

Species.

third fubftance, conftitutes *granitine :* quartz and fchorl compofe *grani-
tello.* See an account of thefe particulars in Sauffure's *Voyage dans les
Alpes*—F.

 2

5. Black porphyry, with large fpots.⌉
6. Black porphyry, with fmall fpots.
7. Coarfe porphyry, of a dirty red, almoft with-
   out fpots, nearly of the fame nature with
   fand-ftone.

Genus V. *Ophites, or Serpentine.*

PLINY gave the name of *ophites* to a kind of ftones
ſpotted like a ferpent's fkin. Bucquet confidered thefe
as a kind of porphyry, but harder, of a more ancient
formation, and having their component parts much
more intimately united than the other kinds. They
have likewife received the name of *ferpentine*, or *hard
ferpentine*. On comparing this ftone with porphyry, it
appears that they are both compofed of a quartzofe
pafte, with feldt-fpar and fchorl; but that in ferpen-
tine the fragments of feldt-fpar and fchorl are large and
rhomboidal, while in porphyry they are very fmall.

Serpentine gives fire with fteel ; its fracture is fine
and half fcaly ; it melts in the fire.

The following are moft of the fpecies of ferpentine
which we have had occafion to fee.

1. Ophites of a deep green ground, with large
   white fpots.
2. Dark green ophites, with oblong fpots of a pa-
   ler green.
3. Ophites refembling the preceding fpecies ; its
   fpots very fmall, and fcarcely vifible: Many

Species.

favage nations ufe it for money : it has recei—
ved the name of *thunder ftone.*

4. Brown ophites, with irregular oblong fpots of a
rofe-coloured white.

We are almoft entirely ignorant of the circumftances
of the formation of ophites.   We know not even whe-
ther it be owing to fire or water.   But as they refemble
porphyry, we have for this reafon placed them imme-
diately after that genus.

ORDER II.   EARTHS *and* STONES *Mixed by* FIRE.

Continuation of the Volcanic Products.

THE origin of thefe fubftances is well known ; they
are never found but in the neighbourhood of volcanoes,
or in places where volcanic fires have formerly exifted.
Befides, they poffefs all the characteriftics of products
of fire.   Thefe, together with the compound ftones a-
bove defcribed, will form a complete lift of volcanic
products.

We include not under this name all the matters which
are found near volcanoes.   Many of them are not al-
tered by fire, fuch as moft of the ftones above defcribed,
more efpecially granite, clay, &c. as well as many faline
fubftances, together with calcined, melted, fublimated,
and vitrified matters.   They exhibit nothing very re-
markable, and were we to defcribe them here, it would
occafion an unneceffary repetition.   We fhall in another
place take notice of their exifting in the neighbourhood
of volcanoes, and of the alterations produced on them
by fubterraneous fire.

Genus

Genus I. *Volcanic Ashes.*

ᴛʜᴇ name of *volcanic ashes* has been improperly
ı to a kind of pulverized earthy matters of various
ırs, which are found in the neighbourhood of vol-
es. They appear to be compofed either of a mix-
of fubftances difcharged from the volcano, or of
altered by the action of air and water. Bucquet
ght them to be combinations of iron and clay.
ʏ are generally attracted by the magnet. We
ʏ only two fpecies of them.

ı.

1. Rapillo, a pulverized matter, of a blackifh
grey, which is found round the edges of vol-
canic craters.

Rapillo contains garnets and fchorls, the form of
which is ftill difcernible, though their angles
have been foftened and incrufted by fome
matter in fufion.

2. Puzzolana. This fubftance has received its
name from the town of Puzzoli, where it has
been made ufe of fince a very remote period :
it is an argillaceous earth impregnated with
iron, and varioufly coloured according as it
contains a greater or lefs proportion of the
metal. There is grey, black, yellow, red,
and brown puzzolana. It melts by fire into
a black enamel. It is ufed to compofe
a kind of cement or mortar, which poffeffes
the property of becoming hard in water. M.
Faujas de St Fond found fome of it in Viva-
rais. He thinks that it is forms [1]

teration and attrition of porous lavas, and
even of bafaltes. That philofopher, in his
refearches on the nature of puzzolana, gives
an account of the proceffes neceffary for build-
ing with it, both under water, and where it
is to be expofed only to the action of the air.

Genus II. *Lavas.*

THIS name is given to matters which have been melt-
ed and half vitrified by volcanoes. They are ufually
fcattered over the fides of mountains, the interior parts
of which are inflamed over with volcanic foci. They
iffue from the craters of volcanoes in burning ftreams,
which fometimes overflow a wide extent of country,
carrying deftruction and defolation wherever they di-
rect their courfe. So confiderable is their bulk, and fo
intenfe their heat, that they cool but very flowly, and are
not quite cool till after feveral years. In cooling, they
crack and feparate into maffes, which are fometimes of
a regular form : and this feems to be the origin of ba-
faltes. In cabinets of minerals there is a great variety
of thefe ftones. They generally confift of a grey pafte,
of a lighter or a deeper fhade ; in grain and hardnefs
fubject to great varieties ; with cryftals or irregular
fragments of fchorl, garnet, glafs, zeolite, &c. inter-
fperfed ; which makes a true mixture. It is impoffible
to point out any certain general properties of lavas;
for they all differ from one another in grain, cohefion,
hardnefs, colour, compofition, &c. They are all in
general very fufible, and afford a kind of blackifh ena-
mel, like volcanic glafs. M. Cadet found them to con-
tain iron, copper, and filiceous and aluminous earth.

Bergman

Bergman believed them to confift of filiceous, alumi-
nous, and calcareous earths, with a mixture of iron.
Many lavas, and more particularly thofe which are the
moft compact, poffefs the property of acting upon the
magnetic needle.

Species.

1. Soft lava of various colours, containing cryftals
   of black fchorl.
2. Soft lava of various colours, containing cryftals
   of green fchorl.
3. Soft lava of various colours, with cryftals of
   white fchorl.
4. Reddifh lava, with blackifh cryftals.
5. Yellowifh faline lava.
6. Soft lava, with garnet cryftals.
7. Porous lava, of a changing luftre (*Fr. Chatoyant.*)
8. Porous grey lava, volvic ftone.
9. Soft blackifh lava, with white cryftals.
10. Grey lava, fomewhat compact, with duodeca-
    hædral, opaque cryftals, or garnets altered by
    fire.
11. Ancient lava, very compact, of a blackifh
    grey, and fpeckled with fpots of a deeper co-
    lour..

Genus III. *Bafaltes.*

There is nothing more inaccurate in the writings
of naturalifts, than their defcriptions of bafaltes. Some
have confounded both fchorls and garnets with this
fubftance. There is no where to be found an accurate
definition of the word *bafaltes*. Some confider them

as products of volcanoes; others think them to be formed by water. The experiments and obfervations of Meffieurs Defmarets and Faujas de St Fond, induce us to prefer the former of thefe opinions. Regularity of form, abfolute opacity, and a confiderable degree of hardnefs, fuch as that it gives fire with fteel, a grey afhy colour, and an evident mixture of fchorls, or fmall fragments of vitrified matter, of a deeper colour than the mafs through which they are interfperfed, may be confidered as the diftinctive characteriftics of bafaltes. They are likewife fufible.

Among this genus there are ftones of enormous bulk, and collected in vaft maffes, which appear to have been formed at fome very remote period in antiquity. Such are, 1. The columns of the Giant's Caufey in the county of Antrim in Ireland. 2. The rock of Pereneire near St Sandoux in Auvergne, which is very accurately defcribed by M. Defmarets. There are others regularly cryftallifed in fmall prifms of three, four, or five faces, &c. : their form, fize, and difpofition, are extremely various.

They are ufually arranged in regular order, one befide another. No analyfis of them has yet been made from which any thing could be determined concerning their nature. They feem to be nothing but lavas apparently cryftallifed, in confequence of the cracks which run through them in all directions while they are cooling *. Their arrangement and amazing va-

<div align="right">rities</div>

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* One theory which has been received concerning the formation of bafaltes, is, that when a ftream of lava pours into the fea, the impulfe of the water caufes it to contract and fplit into regular figures.

<div align="right">But</div>

rieties give confiderable weight to this opinion: it likewife appears, that water infinuating itfelf into the chinks, depofites in them different kinds of earth, and alters the correfponding fides of the bafaltic columns: and this feems to be the caufe that produces the yellow or brown crufts with which they are covered.

Species.

1. Bafaltes in very long polygon prifms, not terminating in regular pyramids.

2. Bafaltes in fhort truncated prifms, of three, four, five, or feven faces.

3. Bafaltes in fhort polygon prifms, terminating on the upper end in a concavity, at the lower in a convexity; articulated bafaltes.

4. Small bafaltes, quadrangular, triangular, &c.; formed by the fracture of the larger columns, and united in the fame group with them *.

Genus IV. *Scoriæ of Lavas.*

The melted matter of which lavas confift is a mixture of various heterogeneous fubftances, diffèring in denfity

But the ingenious M. Houel, in his *Voyage Pittorefque, &c.* fhows this theory to be inconfiftent with facts. He propofes another, in which he afcribes the formation of bafaltic columns to the heterogeneity of the matters of which lavas are compofed. An ingenious theory! but not fufficiently confirmed by facts. —H.

* For the hiftory of thefe ftones, and all the other products of volcanoes, fee an excellent work entitled *Mineralogie des Volcans, par M. Faujas de St Fond. Paris,* 1784.—F.

Of all the above fpecies of bafaltic columns, there are fpecimens be feen in the *King's Park,* near Edinburgh.—H.

denſity and gravity. As it is ſlowly cooled, theſe ſe‐
veral ſubſtances are ſeparated, according to their gra‐
vities. Hence the ſcoriæ of lavas. Theſe are ſpongy
ſubſtances which have not been ſo thoroughly melted as
the lava, and whoſe levity raiſes them to the ſurface of
the maſs. In other reſpects they appear to be of the
ſame nature with lava; the only difference being, that
they are a more imperfect mixture. Scoriæ, as well as
lavas, are found to contain ſchorl and garnet cryſtals.

Species.

1. Ponderous volcanic ſcoriæ, of a compact tex‐
   ture.
2. Black cellular volcanic ſcoriæ.
3. Black ſpongy volcanic ſcoriæ.
4. Black volcanic ſcoriæ, twiſted like a rope.
5. Yellow ochreous volcanic ſcoriæ.
6. Reddiſh volcanic ſcoriæ.
The two laſt ſpecies plainly appear to have ſuf‐
   fered alteration from the contact of air, wa‐
   ter, and acid vapours.

Such was the claſſification of earths and ſtones which
Bucquet thought proper to adopt in the years 1777 and
1778. Great progreſs has ſince been made in the che‐
miſtry of mineralogy. Stones are now analyſed in al‐
moſt every laboratory. Meſſrs Bayen, D'Arcet, Mon‐
net, de Morveau, Sage, Mongez, and Pelletier, in
France; Scheele and Bergman in Sweden; Achard,
Bindheim, and Hupſch, at Berlin; de Sauſſure in
Switzerland; Woulfe, Withering, and Kirwan, in
England, have examined a great number of earths and
ſtones: and in conſequence of theſe analyſes, the claſſi‐
ſication

cation of earths and ftones muft undergo a confiderable change. Two of thofe chemifts have therefore publifhed new fyftems of mineralogy, in which their arrangements are founded on the nature of the component principles of minerals. But their methods are totally different from that of Bucquet, who fought to affociate exterior characteriftics with chemical properties. Bergman and Kirwan have paid no regard to phyfical qualities; the nature, the quantity, and the proportion of the component principles are the particulars on which they found their arrangements. Their fyftem, though it may contribute greatly to the advancement of chemical knowledge, cannot teach us to diftinguifh ftones by their appearance and fenfible properties. It was therefore abfolutely neceffary to give, as we have done, fome phyfical method, before entering on the examination of thefe fyftems. The one throws light on the other; and they may thus be equally ufeful to the ftudent of mineralogy.

§ II. Bergman's *Chemical arrangement of Earths and Stones*.

Bergman, after fhowing that external properties, if judicioufly felected, may be *of ufe* in forming a claffification of minerals, but are not of themfelves *fully adequate* to that purpofe, eftablifhes his principal divifions

of

* This fection is an extract from Bergman's work, publifhed in French, by M. Mongez, under the title of *The Mineralogift's Manual, &c.* F.——There is an Englifh tranflation of it by Dr Withering.—H.

of claffes and genera on the compofition and intimate
qualities of thofe bodies. Every mineral is arranged
by that principle which is the moft powerful, or the
moft copious in its compofition : all minerals, or foffils,
are in this fyftem divided into four claffes; falts, earths,
bitumens, and metals. We fhall here take notice of
none but the earths.

Bergman acknowledges five different kinds of fimple
earth; terra ponderofa, lime, magnefia, clay, and fili-
ceous earth *.

He firft examines each of thefe as pure earths, though
none of them is ever found fuch in nature : he ob-
ferves, that thefe five earths combine into twenty diffe-
rent fpecies, ten of two, fix of three, three of four,
and one of the whole five. But he ranges among the
fpecies of earths all fuch of their combinations with
acids as are not foluble in one thoufand times their own
weight of boiling water; and thofe fpecies are thus
increafed to a vaft number. Befides, two compound
earths, though made up of the fame component prin-
ciples, may differ widely as to the proportion in which
thefe principles exift in them; even fo much as to be
effentially different in their nature. Thefe are the
grounds on which Bergman and his commentator the
Abbé Mongez, have diftinguifhed earths into different

<div style="text-align: right">fpecies,</div>

* Three of thefe five kinds of earth appear plainly to poffefs faline
properties, namely, *larytes* or ponderous earth, magnefia. and lime;
and we therefore referve the hiftory of them to the fecond part of the
work. Bergman, whofe intention was to divide ftones according to
their principles, was obliged to rank them among the earths, becaufe
they are often united with each other. Many of the fubftances which
that illuftrious chemift has placed among ftones, come in our method
to be confidered as falts.—F.

fpecies; for Mongez has made confiderable additions to the labours of the Swedifh chemift. The following are the fpecies into which they divide each of the primary earths.

Ponderous Earth *.

I. Pure ponderous earth. This is no where to be found in nature; it is obtained, as we fhall afterwards fee, by decompofing ponderous fpar.

II. Aërated ponderous earth; a combination of terra ponderofa with the aërial acid. This compound has not hitherto been found in nature: Bergman thinks that it may exift in water in a ftate of folution †.

III. Vitriolated ponderous earth; ponderous fpar: a combination of ponderous earth with the vitriolic acid. Abundance of this fubftance is found in mines. The Bologna ftone is a variety of it.

IV. Vitriolated ponderous earth, containing petroleum, mixed with felenite, alum, and filiceous earth; the hepatic ftone of Cronftedt. This is a bright yellow, brown, or black

Vol. I.   S   fparry

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* We fhall here follow the denominations of Bergman. It will be eafy to refer the ancient names both of earthy bafes and of the acids united with them, to the new and methodical denomination, which we fhall give thofe bodies in the hiftory of faline matters. See the end of this volume, and the fecond.—F.

† A natural compound precifely of this fpecies has been found in England fince the death of Bergman. See the extract from Kirwan's Mineralogy.—F.

fparry fubftance; ftrong fmelling, and not
effervefcent with acids.   A quintal of this
natural compound contains, according to
Bergman, 33 parts of filiceous earth, 29 of
pure terra ponderofa, and 5 of clay, befide
lime, water, and vitriolic acid.

Lime.

   I. Pure or quick-lime. Bergman knew not whe-
ther this fubftance exifted in nature.

  II. Aërated lime; chalk, or calcareous earth; a
combination of lime with the aërial acid.
It often contains marine falt of magnefia,
calcareous marine falt, clay, and filiceous
earth or iron.   In the bowels, or on the fur-
face of the earth, it conftitutes lac lunæ, con-
gelations, calcareous ftones, marbles, calca-
reous fpars, concretions or ftalactites, &c.

III. Bituminous aërated lime, or lime impregnated
with petroleum; fwine-ftone. It is found
in France at Villers-Cotterets, Plombieres,
and Ingrande in Anjou; at Rattwik in Da-
lecarlia, Kinekulle in Weftrogothia, Kraf-
nafelo in Ingermania, in Portugal, in Swe-
den, &c. If violently rubbed, or heated, it
diffufes a fetid fmell, which fometimes af-
fects the noftrils in the fame manner as
cat's urine; and fome authors have there-
fore given it the name of *lapis felinus.* It
effervefces with acids, decrepitates, and lo-
fes its fmell and colour in fire.   When dif-
tilled

tilled in large quantities, it affords, 1. A
fetid liquor, which turns the fyrup of vio-
lets green, and effervefces with acids; 2. A
blackifh oil, of a ftrong fmell, refembling
that which is obtained from pit-coal; 3. Con-
crete volatile alkali. The refidue contains a
little marine falt. This fubftance owes its pe-
culiar properties to the bitumen mixed with it.

IV. Fluorated lime; fluor mineral, or vitreous fpar.
A combination of lime with the fpathofe or
fluoric acid, with a mixture of clay and filice-
ous earth, and a little of the marine acid.

V. Lime faturated with a peculiar acid, probably
metallic *; ponderous ftone; Swedifh *Tung-
ften*. This is the weightieft of all ftones. It
is found in fmall yellow or red grains in the
mines of Baftnaes, near Kitterhute in Weft-
mania; at Marienburgh and Altenburgh in
Saxony; it is fparry, bright, and whitifh. It
is often confounded with white tin ore. It
fcarce yields to the action of fire, and is vitri-
fiable only at the furface: it is not foluble in
boiling water; the vitriolic acid feparates the
lime: by diffolving it in volatile alkali, preci-
pitated by the nitrous acid, a white powder is
obtained, which is the peculiar acid difcover-
ed by Scheele. In order to recognize and dif-
tinguifh it from other ftones, we muft firft re-
duce it to powder, and then pour upon it a

S 2   due

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* Found to be fo.   See Scheele's Effays, and De Layet'een V
um, both tranflated into Englifh.—H.

due quantity of the nitrous or of the marine
acid. This mixture, when gently heated, af-
fumes a fine yellow colour. (See *Le Journal
de Phyfique*, 1783, *tome* 22.)

VI. Aërated lime, contaminated * with a fmall
mixture of muriatic magnefia, or marine falt
of magnefia.

VII. Aërated lime, contaminated with clay; falfe
marl.

VIII. Aërated lime, contaminated with filiceous
earth. Some hewing ftones and marbles give
fire with fteel, on account of the fragments
of filex or quartz which they contain.

IX. Aërated lime, contaminated with a mixture of
argillaceous and filiceous earth; perfect marl.

X. Aërated lime, contaminated with iron and
manganefe: falfe white iron ore; black and
dufty, or hard, red, or whitifh. The mines
of Hallefors exhibit thefe varieties †.

Magnefia.

I. Pure magnefia. This is always a product of art.

II. Aërated magnefia, diffolved in water faturated
with aërial acid.

III. Aërated

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* The word contaminated, *inquinatus*, is ufed by Bergman to de-
note the mixture of two or more earths, when no real combination
takes place. We fhall therefore fometimes fubftitute the word mixed
in its place.—F.

† All thefe fpecies are faline fubftances, which will be defcribed in
the hiftory of falts.—F.

Species.

III. Aerated magnesia, mixed with filiceous earth. It scintillates and effervefces.

IV. Magnesia, intimately combined with clay and filiceous earth ; fteatites, Briançon chalk, foap-ftone, lapis ollaris, ferpentine, lapis nephriticus.

V. Magnesia, combined with a confiderable portion of filiceous earth, and a fmaller quantity of calcareous and argillaceous earth, and contaminated with calx of iron. Afbeftos ; mountain cork ; mountain leather ; amianthus. Bergman found a quintal of amianthus to contain 64 parts of filiceous earth, $18\frac{4}{7}$ths of magnesia, $6\frac{9}{10}$ths of lime, 6 of vitriolated ponderous earth, $3\frac{1}{10}$ths of clay, and $1\frac{1}{7}$th calx of iron ; a quintal of afbeftos afforded 67 parts of filiceous earth, $16\frac{4}{7}$ths of magnesia, 6 of clay, 6 of lime, $4\frac{1}{7}$ of calx of iron.

VI. Magnesia mixed with argillaceous and filiceous earth, and with pyrites ; a kind of ore of alum defcribed and analyfed by M. Monnet, *(Syft. de Mineralogie, genre 9. page 161).*

VII. Magnesia mixed with argillaceous and filiceous earth, pyrites, and petroleum ; magnesian aluminous fchiftus.

Clay.

I. Pure clay. It is precipitated from alum by aërated volatile alkali.

II. Clay mixed with filiceous earth. Porcelain earth ; Chinefe kaolin. Solid clay from Saint-

trien

Iriez in the Limoufin, from Japan, and from
Saxony.   Pulverulent clay from Weftmania,
Boferap, and China.   Thefe earths are often
mixed with mica.   Clays for potteries and
delft-ware are coarfer, but of a fimilar nature.

III. Clay mixed with iron and filiceous earth. Boles
or bolar earth, grey, yellow, red, brown, and
black.   Thefe, when wafhed, become terræ
figillatæ.   Common clays, of a green, blue,
or red colour, are of this fpecies.

IV. Clay mixed with filiceous and calcareous earths.
Argillaceous marl ; pipe clay ; agaric mineral
or foffil.

V. Clay mixed with filiceous and magnefian earth.
Lemnian earth ; fuller's earth ; foap-ftone ;
fmeΦites.   Bergman obtained from Lemnian
earth, Hampfhire clay, and Englifh fuller's
earth, a confiderable quantity of filiceous
earth, about ⅞th of clay, and as much aëra-
ted lime, with $\frac{1}{15}$th of aërated magnefia, and
the fame quantity of oxide of iron.   He gives
to thefe earths the generic name of *lithomarga.*

VI. Clay contaminated with fulphur and vegetable
alkali : alum ore of Tolfa and Solfaterra.
Bergman takes it to be a volcanic product.

VII. Clay mixed with filiceous earth, pyrites, and
petroleum ; aluminous fchiftus.   It is found
in Italy, in the diftrict of Liege ; in Sweden,
and in Jemteland.   Black crayons, fuch as
thofe from Bechel near Seez in Normandy,
and the ampelites, are of this fpecies. Tripo-
li

pecies.

lis are of the fpecies of aluminous fchifti, more
or lefs burnt. Such are thofe of Poligné in
Normandy and of Menat in Auvergne.

M. Mongez comprehends under this fpecies,
thofe fchifti which contain much clay, and
more or lefs filiceous earth and bitumen. Moft
of them contain likewife a mixture of calca-
reous earth, and effervefce with acids. The
proportions in which the component principles
are mixed in thefe fchifti are extremely vari-
ous. Some of them are fo bituminous, that
they burn with flame ; others are full of py-
rites, and effervefce in the air ; fome again
are exceffively hard, and give fire with fteel.
M. Mongez admits five varieties : 1. Hard ar-
gillaceous fchiftus, or writing flate : 2. Soft
argillaceous fchiftus, or flate for roofing houfes :
3. Soft filiceous fchiftus, ufed in polifhing me-
tals : 4. Hard filiceous fchiftus, ufed for whet-
ting razors ; fcythe-ftone : 5. Hard calcare-
ous fchiftus, which makes an indifferent lime,
fuch as that of Allevard in Dauphiny.

VIII. Clay combined with nearly half its weight of
filiceous earth, a little aërated lime, and fome
oxide of iron ; cryftal gems. Bergman's fine
difcoveries concerning the nature of cryftal
gems, which, from their exceffive hardnefs
and apparent inalterability, were formerly
though not to be fufceptible of a chemical a-
nalyfis, have been confirmed by the experi-
ments of Meffrs Margraf, Gerhard, and Achard.

The

The following is the reſult of Bergman's ana‑
lyſis of the five cryſtal gems, which are varie‑
ties of the ſpecies we are now conſidering.

	Clay.	Silic.	Lime.	Iron.	
Oriental emerald contains	60	24	8	6	100th parts.
Oriental ſapphire -	58	35	5	2	
Saxon topaz - -	46	39	8	6	
Oriental hyacinth -	40	25	20	13	
Oriental ruby -	40	39	9	10	

The means employed by this ingenious che‑
miſt for reſolving ſtones into their component
principles, though very ingenious are very
ſimple.   (See *le Journal de Phyſique*, 1779,
tome 14. *p.* 268 *; tome* 21. *p.* 56 *et* 101) *.

IX. Clay combined with a portion of ſiliceous earth,
    equal to more than half the weight of the
    whole maſs, with a very ſmall quantity of aë‑
    rated lime and ſome iron; garnet, ſchorl,
    tourmalin.   In theſe ſtones the proportion of
    the iron varies.   See the analyſis of the Tour‑
    malin of Tyrol, *by M. Muller, Journal de Phy‑
    ſique, tome* 15. *p.* 182. *ann.* 1780.

X. Clay ſlightly combined with half the weight
   of the maſs, or rather more, of ſiliceous
   earth, and a ſmall quantity of lime ; zeolite.
   M. Mongez conſiders the azure ſtone, *lapis
   lazuli*, as a zeolite.   M. Margraaf found a
   ſmall quantity of gypſum, ready formed in
   the *lapis*.

* Or rather Bergman's F

secies.

XI. Clay combined with a confiderable quantity of filiceous earth and a little magnefia ; talc, mica. The proportion in which the principles exift in this ftone is not yet perfectly determined.

Genus V. *Siliceous Earth.*

I. Pure filiceous earth. This is obtained by melting white quartz with four parts of fixed alkali, diffolving the whole in diftilled water, and precipitating the earth with an acid. The precipitated earth is then wafhed and thoroughly dried.

II. Siliceous, united with a very fmall proportion of argillaceous and calcareous earth : The feveral varieties of rock-cryftal, of quartz, and of grit-ftone.

III. Siliceous, united with argillaceous earth. Hydrophanes chalcedony, or *oculus mundi*: according to M. Gerhard of Berlin, this ftone contains a greater quantity of clay than of filiceous earth. Opal: M. Mongez confiders cat's eye, fifh's eye, and girafol, as varieties of this ftone. To thefe three he adds agate and its varieties; cacholong, carnelian, fardonyx, gun-flint, and jade. They have not as yet been analyfed with fufficient accuracy.

IV. Siliceous earth united with clay ftrongly impregnated with iron ; jafper. M. Mongez

3   fiders

confiders the finople as a variety of the jaf-
per.

V. Siliceous earth united with fuch a quantity of
martial earth as renders it ponderous; falfe
jafper. M. Mongez calls this ftone a me-
tallic quartz. He diftinguifhes it into the
black coloured by iron, and the red-coloured
by copper.

VI. Siliceous united with argillaceous earth, and
a little lime; petrofilex. This ftone fome-
times gives fire with fteel, and effervefces
with acids. It melts in a ftrong fire.

VII. Siliceous earth united with clay, and a little
magnefia ; feldt-fpar. It fuffers a change of
colour, and melts in the fire. Air does not
decompofe it. It gives fire with fteel, and
breaks at every ftroke.

VIII. Siliceous earth, united with magnefia, aëra-
ted and fluorated lime, and a portion of oxide
of copper and iron; prafe, chryfoprafe.
Bergman gives the compofition of this ftone
from an analyfes of it by M. Achard.

I. APPENDIX.

BERGMAN, in his firft appendix treats of mineral
fubftances mechanically mixed or united, in fuch a man-
ner that the principles of the mixture or compofition
may be at once diftinguifhed by ocular obfervation.
We fhall mention none but mixtures of earths ; fuch
are the ftones known by the name of rocks, *faxa*. M.
Mongez, who has made confiderable additions to what

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Bergman had done on this head, diftinguifhes thefe ftones or rocks into two genera. 1. The firft, thofe whofe parts are not united by any cement, but fimply adhere by juxta-pofition. Thefe are formed by the agglutination of a number of fragments. He diftinguifhes them into three fpecies,—granite, gneis of Saxony, and horn-ftone. 2. His fecond genus comprehends fuch mixed ftones as have their parts incrufted in a common cement; as is the cafe with the four fpecies of porphyry, ophites, or ferpentine, breccia, and pudding ftone. We fhall here give the varieties of thefe ftones acknowledged by this naturalift.

I. GRANITE is a compofition formed by the union of quartz, feldt-fpar, mica, fchorl, and fteatites, mixed in various proportions; confifting fometimes of two of thefe fubftances, fometimes of three, and fometimes of four. Quartz is always the bafe.

Variety I. Granite of two fubftances; granitine.
    A. Quartz and feldt-fpar.
    B. Quartz and fchorl.
    C. Quartz and mica.
    D. Quartz and fteatites.

Variety II. Granite of three fubftances.
    Quartz, feldt-fpar, and mica. This is the moft common, the moft plentiful, and the moft varied of all.
    B. Quartz, mica, and fchorl.
    C. Quartz, fchorl, and fteatites.

<div align="right">Variety</div>

Variety III.   Granite of four fubftances.
    A. Quartz, feldt-fpar, fchorl, and mica.
    B. Quartz, feldt-fpar, fchorl, and fteatites.

II. GNEIS is a mixture of quartz in grains, and mica in a greater or lefs proportion, with a confiderable quantity of clay or fteatites, which conftitutes the bafe of the ftone.   This ftone is foliated like the fchiftus.   Expofure to the air foon alters and waftes it down, becaufe the clay abforbs moifture.   Many varieties of the gneis are found on the Alps of Dauphiny.

III. HORN-ROCK is a compact ftone, confifting of very minute particles of an earthy afpect, and exhibiting over its furface fparkling points of mica.   When moiftened or ftruck, it diffufes a clayey fmell.   It hardens in the fire like clays, and when expofed to a very ftrong heat, melts into a blackifh fcoria or a black glafs.   Its colours are extremely various.   M. Mongez thinks the Swedifh *trapp* a variety of the horn-ftone.

IV. PORPHYRY feems to be compofed of a fine hard pafte of the fame nature with red jafper, containing either irregular or cryftalline grains of quartz, of white or reddifh feldt-fpar, and fometimes of green or black fchorl.

V. OPHITES, or ferpentine, is a fpecies of porphyry, of a green pafte, and greenifh white fpots.   The fpots of the ophites are generally oblong ; whereas the porphyry are fquare or rhomboidal.
ftone is a variety of this fpecies.

VI. Breccia, from the Italian word *briccia*, a crumb or fragment. This is a mixed ftone of a much later formation than any of the above, formed of the ruins of the primary mountains, of irregular worn pieces of filex, &c. united by a common cement. M. Mongez makes no fpecific diftinction between breccias and pudding-ftones ; but gives to the latter a compound name, indicating the nature both of their fragments and of their cement. He diftinguifhes thefe ftones into eight varieties : The calcareo-calcareous breccia, under which denomination both the breccia properly fo called and the lumachello are included ; the filiceo-filiceous breccia, or the pudding-ftone* ; the breccia confifting of calcareous and filiceous fragments, with a calcareous cement ; the breccia with filiceous cement, and fragments of the calcareous and filiceous genus ; the arenario-filiceous breccia,—of this variety is the grey ftone of Chartres ; the breccia with a cement and fragments of jafper ; the breccia with a cement and fragments of porphyry ; and the volcanic ·breccia.

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II. APPENDIX.

Volcanic Products.

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M. Mongez, with Bergman, divides volcanic products into fuch as are formed by fire, and fuch as owe

their origin to water. The laſt are nothing but earthy matters, which having been diſſolved or ſuſpended in water, are by it depoſited in places adjacent to volca- noes, and among volcanic products: of this kind are the calcareous and ſiliceous incruſtations, as well as the zeolites which are often found among volcanized ſub- ſtances.

M. Mongez divides the genuine products of volca- noes into three orders: 1. Earthy ſubſtances, but little altered by fire; ſuch as calcareous matters, clays, gar- nets, hyacinths, ſchorls, and mica. 2. Earthy ſub- ſtances which have been burnt and calcined; ſuch as volcanic aſhes or rappillo, and puzzolana, the tufa, the peperino of the Italians, pumice-ſtone, and the white earth which covers ſolfatara. 3. Earthy ſubſtances which have been in a ſtate of fuſion, or lavas; and of theſe he admits ſeveral kinds,—the ſpongy lava, the compact lava, the lava in ſtalactites, and volcanic glaſſes. After theſe diviſions, he mentions ſuch earthy volcanic products as are of an uncertain origin. Un- der this order he reckons particularly volcanic ſchorls, and ſtill more baſaltes, which he takes to be maſſes of trapp ſoftened by the humid vapours of volcanoes, and ſlowly dried after theſe have ceaſed to exhale.

§ III.   *Chemical Claſſification of Earths and Stones, by Mr* Kirwan.

In the year 1784, Mr Kirwan, a celebrated chemiſt of London, publiſhed a work on mineralogy; in whi he gives a general claſſification of miner on their chemical properties or combi

part of his work contains earths and ftones. He gives infipidity, drynefs, fragility, incombuftibility, and infolubility, as the characteriftic properties of thefe fubftances. With Bergman, he diftinguifhes five genera of fimple earths,—calcareous earth, ponderous earth or. barytes, magnefia or muriatic earth, argillaceous earth, and filiceous earth. From a chemical analyfis, he arranges all known earths and ftones under thefe five genera.

CALCAREOUS GENUS.

To this he refers twelve fpecies.

Species.

I. Calcareous earth, not combined with any acid; virgin lime of volcanoes. *Falconer on Bath Waters, vol.* i. *p.* 156, 157 ; *Monnet. Mineral. p.* 515.

II. Calcareous earth, combined with aërial acid. Its varieties, which he arranges in two feries, are tranfparent calcareous fpar, opaque fpar, ftalactites, tophi, incruftations, petrifactions, agaric mineral or ghur, chalk, limeftone, and marbles. *Bayen, Journal de Phyfique, tome* ii. *p.* 496.

III. Calcareous earth combined with the vitriolic acid, gypfum, felenite, or plafter *. He admits two feries ; the tranfparent and the opaque.

IV. Calcareous earth combined with the fparry acid, fluor fpar, petuntze of Margraf. Series

I.

I. Tranfparent fluor fpars : II. Opaque fluor fpars.

V. Calcareous earth combined with the acid of tungften. Tungften or ponderous ftone. *Woulfe, Phil. Tranf.* 1779, *p.* 26. ; *Scheele's Effays.*

VI. Aërated calcareous earth, mixed with a dif-cernible quantity of magnefia. Var. I. Compound fpar, defcribed by *Mr Woulfe, Phil. Tranf.* 1779, *p.* 29. II. Creutzwald ftone, analyfed by *M. Bayen* †, *Jour. de Phyf. tome* xiii. *p.* 59.

VII. Aërated calcareous earth, mixed with a dif-cernible quantity of clay. Var. I. Calca-reous marl. II. Traveftino, margodes, ftony marl. *Ferber's Travels in Italy, p.* 117, 119.

VIII. Aërated calcareous earth, mixed with a dif-cernible quantity of ponderous earth ; barytic marl of Derbyfhire.

IX. Aërated calcareous earth, mixed with a dif-cernible portion of filiceous earth. Var. I. Stellated fpar. II. Calcareous grit ; hard free-ftone, *Moilon. Monnet, Mineralogy, p.* 116.

X. Aërated calcareous earth, mixed with a fmall quantity of petroleum. Swine-ftone.

XL

† It would be fuperfluous to give here the proportions in which the feveral principles are united in thefe ftones, as we will have occa-fion to mention them in the chemical hiftory of falts. We fhall give the proportions only in Mr Kirwan's two laft genera, which we con-fider as genuine earths.—F.

Species.

XI. Aërated calcareous earth, mixed with a dif-
cernible quantity of pyrites; *pierre de St.
Ambroix*, analyfed by the *Baron de Servieres,
Journ. de Phyf. tome* xxi. *p.* 394.

XII. Calcareous earth, mixed with a difcernible
portion of iron. Var. I. Aërated calcare-
ous earth impregnated with iron, *Rinman,
Mem. de Stock.* 1754. II. Tungften im-
pregnated with iron, *Cronftedt, Mem. de
Stock.* 1751.

To thefe twelve fpecies of calcareous earth, Mr Kir-
wan adds fix fpecies of compound ftones, in which cal-
careous earth predominates. 1. Mixtures of the fim-
ple calcareous fpecies, fuch as felenite and chalk, vitre-
ous fpar and tungften. 2. Compounds made up of the
calcareous and barytic fpecies. Of this kind is a yel-
low ftone of Derbyfhire, formed of chalk with fmall
lumps of ponderous fpar. 3. Compounds of the calca-
reous and magnefian fpecies; white marble mixed with
fteatites, the *pietra telchina*, and the *verde antico*. 4.
Compounds of the calcareous and the argillaceous fpe-
cies, of chalk and fchiftus; fuch as the green campan
of the Pyrenees, the red campan, Florence marble, the
griotte, the amandula, the cipolin of Rome (fee *Bayen,
Journ. de Phyfique, tome* xi. *p.* 499. 801, *et tome* xii.
p. 51, 56, *et* 57.); of chalk and mica, as the cipolin
marble of Autun, the macigno, the pietra bigia, and
the columbina or turchina of the Italians. 5. Compounds
of the calcareous and the filiceous fpecies; fcintillating
marbles, marble with a mixture of lava. 6. Laftly,

compounds of calcareous earth, with two or more of the other genera ; ſuch as calcareous porphyry, and the lime-ſtone mixed with mica.

BARYTIC GENUS.

Under this genus he reckons ſix ſpecies.

Species.
I. Ponderous earth combined with the aërial acid. A ſtone found by Dr Withering on Alſton Moor in Cumberland.

II. Barytes combined with the vitriolic acid. Ponderous ſpar.

III. Barytes combined with the ſpathoſe acid. This ſubſtance exiſts not in nature, but is a product of art.

IV. Barytes combined with the acid of tungſten. This is obtained in the ſame manner as the preceding.

V. Aërated barytes, mixed with a diſcernible quantity of ſilex and iron. Bindheim.

VI. Ponderous ſpar, mixed with ſilex, mineral oil, and earthy ſalts. Hepatic ſtone, white, grey, yellow, brown, or black.

MURIATIC or MAGNESIAN GENUS.

Mr Kirwan reckons eight ſpecies of this genus, arranging under it both thoſe earths and ſtones in which magneſia predominates, and thoſe which, though containing more ſilex than magneſia, yet exhibit all the characteriſtics of the magneſian genus.

Species

:cies.

I. Magnefia combined with the aërial acid, and mixed with other earths. Var. I. Mixed with filex ; *fpuma maris.* The Turkifh tobacco-pipes, and the Canadian pipe, are compofed of this fubftance. II. Mixed with calcareous earth and iron; olive-coloured and bluifh earth near Thionville. III. Mixed with clay, talc, and iron; greenifh yellow Silefian earth.

II. Magnefia combined with the aërial acid, with above four times its weight of filex, and a fmall proportion of clay. Var. I. Steatites. II. Lapis ollaris.

III. Aërated magnefia combined with filex, calcareous earth, and a fmall proportion of clay and iron. Var. I. Fibrous afbeftos. II. Coriaceous afbeftos ; mountain cork.

IV. Aërated magnefia, combined with filex, aërated calcareous earth, barytes, clay, and iron. Amianthus.

V. Pure magnefia, combined with a quantity of filex, more than equal to its own weight, a third part of clay, nearly a third of water, and one or two tenths of iron. Serpentine, *lapis nephriticus,* Italian gabro.

VI. Pure magnefia, combined with twice as much filex, and lefs than an equal quantity of clay. Venetian talc, Mufcovy talc.

VII. Magnefia combined with the fparry acid. This fubftance is not found in nature.

VIII. Magnefia combined with the acid of tung-

ften. This fubftance is not known to exift
in nature.

To thefe eight fpecies, Mr Kirwan adds five others,
compounds in which magnefia predominates. 1. Com-
pounds of the feveral fpecies of magnefia with one ano-
ther; fteatites and talc, Briançon chalk; ferpentine
with fteatites or afbeftos. 2. Compounds of the mag-
nefian with the calcareous fpecies; red or yellow fer-
pentine, with fpots of white calcareous fpar, *potzovera;*
the black is the *Nero di prato*, and the green the *verde
di fuza* of the Italians. 3. Compounds of the magne-
fian and the barytic fpecies; ferpentines with fpots or
veins of ponderous fpar. 4. Compounds of the mag-
nefian and the argillaceous fpecies; fteatites mixed
with clay, mica, or fchiftus. 5. Compounds of the
magnefian with the filiceous fpecies; ferpentine veined
with quartz, feldt-fpar, or fchorl,

ARGILLACEOUS GENUS.

Mr Kirwan reckons fourteen fpecies of this genus.

Species.

    I. Clay faturated with the aërial acid; *lac lunæ,*
       according to Schreber's analyfis.

    II. Clay combined with the aërial acid, and mix-
       ed with filex and water; potter's clay, pipe
       and porcelain clay, &c.

    III. Clay faturated with the vitriolic acid; em-
       bryon alum in fcales like mica. *Baumé.*

    IV. Clay faturated with the marine acid; maria
       embryon alum.

:cies.

V. Clay combined with about one part and an half of filex, nearly one part of magnefia, and half a part of dephlogifticated iron; mica.

VI. VII. VIII. IX. Clay combined with filiceous earth, magnefia, calcareous earth, iron, or a bitumen; flate, blue fchiftus, pyritous fchiftus, bituminous fchiftus, and argillaceous fchiftus.

X. Clay combined with a little filex, magnefia, and calcareous earth, with a quantity of iron calx, nearly equal in weight to the clay; horn-ftone, or *horn-blende.*

XI. Clay combined with a quantity of filex equal to four times its own weight, with half its weight of calcareous earth, and fomewhat more than its weight of iron ; toadftone.

XII. Clay united to from twice to eight times its own weight of filex, half its weight of lime, and once or twice its weight of water; zeolite.

XIII. Clay united with four times its own weight of filex, and one third of iron ; pitch-ftone, lava.

XIV. Clay mixed with a difcernible portion of red iron calx, and fometimes with fteatites ; red chalk.

To thefe Mr Kirwan adds fix compound fpecies in which the argillaceous genus predominates.

SILICEOUS GENUS.

This genus in Mr Kirwan's ſyſtem, comprehends twenty-ſix ſpecies,

Species,

I. Siliceous earth nearly pure; quartz, cryſtal ſand.

II. Siliceous earth, with one-fourth clay, and one-fortieth calcareous-earth; ſilex, gun-flint, See *Weigleb. Act. nat. Curiof. t. 6. p.* 408.

III. Siliceous earth, with from one-fourth to one-third clay, and from one-twelfth to one-fifteenth calcareous earth; petroſilex,

IV. Siliceous earth, with one-third clay, and one-ſixth or one-ſeventh iron calx; jaſper.

V. Fine filiceous earth, mixed in various proportions with iron and other earths; agate, opal, chalcedony, onyx, carnelian, and ſardonyx. Precious ſtones of the ſecond order.

VI. Siliceous earth, with from an equal quantity, to nearly three times its own weight of clay, from a ſixth part to an equal quantity of calcareous earth, and from one-eighteenth to an equal quantity of iron; ruby, topaz, hyacinth, emerald, ſapphire. Precious ſtones of the firſt order.

VII. Amethyſt. The principles of its compoſition are not yet known.

VIII. Siliceous earth, with one fifty-fifth of calcareous earth, a ſmaller quantity of magne-

fecies.

fia, and a very fmall quantity of iron, copper,
and fparry acid ; chryfophrafe.

IX. Siliceous earth, with blue fluor fpar, and a
little gypfum; *lapis lazuli.* M. Margraf
found in it chalk, gypfum, filex, and iron.
M. Rinman obferved it to contain a portion
of the fparry acid.

X. Jade. M. Kirwan conjectures it to confift of
filex, magnefia, and iron.

XI. Siliceous earth, with clay, ponderous earth,
and magnefia; feldt-fpar, petuntze, and La
bradore ftone. 100 parts of feldt-fpar contain
67 parts of filex, 14 of clay, 11 of ponderous
earth, and 8 of magnefia.

XII. Siliceous zeolite. This fubftance is found at
Mæffiberg. It differs from the true zeolite
in giving fire with fteel, which the other does
not; and this property is a proof that filex
is one of its principles.

XIII. Siliceous earth, with clay equal to more
than a third part of its weight, and one-ninth
of chalk, with no iron ; white garnet of
Mount Vefuvius. 100 parts of it contain, ac-
cording to Bergman, 55 of filex, 39 of clay,
and 6 of chalk.

XIV. Siliceous earth with clay, chalk, and one-
tenth of iron, garnet. Bergman fays that
100 parts of this ftone contain 48 of filex, 30
of clay, 12 of calcareous earth, and 10 of
iron.

T 4. XV.

Species.

 XV. Siliceous earth, with a good deal of clay,
nearly one-tenth of chalk, and a little iron
and magnefia; fchorl.

 XVI. Bar fchorl, German *ftangen fhoerl;* found by
M. Fichtel on the Carpathian mountains. It
is found among lime-ftone, is of a prifmatic
form, and gives a flight effervefcence with
acids. M. Bindheim obtained from 100 parts
of this fchorl, 61 of filex, 21 of chalk, 6 of
clay, 5 of magnefia, 1 of iron, and 3 of water.

 XVII. Tourmalin. The following are, according
to Bergman, the proportions of the princi-
ples of the tourmalins of Tyrol, Ceylon, and
Brazil.

	Clay.	Sil.	Cal. E.	Iron.	
Tourmalin of Tyrol	42	40	12	6	⎫
———— of Ceylon	39	37	15	9	⎬ 100dth parts.
———— of Brazil	50	34	11	5	⎭

 XVIII. Bafaltes, trapp. 100 parts contain, ac-
cording to Bergman, 52 of filiceous earth, 15
of clay, 8 of calcareous earth, 2 of magnefia,
and 15 of iron.

 XIX. Rowly rag. A grey granulated ftone,
which heat renders magnetic and melts, and
which in the air acquires an ochreous cruft.
100 parts of it, according to Withering, con-
tain 47.5 of filiceous earth, 32.5 of clay, and
20 of iron.

 XX. Silex, clay, iron, and calcareous earth, melt-
ed together by volcanic fire.

ies.

1. Cellular lavas, improperly called pumice-
   ftones. Thefe have been very imperfectly
   melted. Bergman found them to contain
   from $\frac{45}{100}$ to $\frac{10}{100}$ of filex, from $\frac{15}{100}$ to $\frac{10}{100}$ of
   iron, $\frac{4}{100}$ or $\frac{1}{100}$ of pure calcareous earth;
   and the reft of the compofition, clay.
2. Compact lavas. Thefe have undergone a
   fecond fufion, and have therefore but few
   cavities. They found when ftruck.
3. Vitreous lavas, or lava entirely melted into
   black, green, blue, &c. glafs. M. Sauffure,
   by melting together, more or lefs thorough-
   ly, certain quantities of horn-rock, marl,
   and fchiftus, has produced imitations of
   thefe lavas. (*Voyage dans les Alpes, p.* 127).

XXI. Siliceous earth, united with about a tenth
   part of magnefia, and a very fmall portion of
   calcareous earth ; pumice ftone.

XXII. Siliceous earth, with lefs than its own weight
   of magnefia and iron ; martial magnefian fpar.
   Pifolite found at Sainte Maire, by M. Maret.

XXIII. Siliceous earth, with one third its own weight
   of aërated calcareous earth ; Turkey ftone.
   Oil hardens it.

XXIV. Siliceous earth, mixed with a little iron and
   calcareous earth. Rag-ftone.

XXV. Quartz confolidated with lefs than its own
   weight of calcareous earth or clay, and a lit-
   tle iron ; grit reducible to fand by pounding
   Var. I. Grit with a calcareous cement ; of
   Fontainebl   with acids. II.

   ▶ With

        With an argillaceous cement. This variety
        does not effervesce. It is used for building,
        for whet-stones, and for filtering water, &c.

XXVI. S.liceous earth consolidated with semi-phlogif-
        ticated calx of iron; brown or black scintil-
        lating stone, which becomes red and exfoli-
        ates in the air. Semi-phlogisticated iron ag-
        glutinates earths ; but iron, when very much
        calcined, possesses not the same agglutinative
        power. This fact has been demonstrated by
        Messrs Edward King and Gadd.

To these twenty-six species of the siliceous genus, Mr.
Kirwan annexes six other species in which that earth
predominates. The varieties which he includes under
these species, are compounds frequently found in moun-
tains of ancient formation. The English chemist draws
this supplement to the siliceous genus from M. Sauffure's
observations on the Alps. Among these varieties are,
the several kinds of granite, pudding-stones, granitelloes,
granitines, porphyry, gneis, variolite, &c *.

                                          C H A P.

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* Since the publication of the fourth edition of M. Fourcroy's
work, Mr Kirwan has published a new edition of his Elements of Mi-
neralogy, in which his system is greatly altered and enlarged.
    In this edition he enumerates nine simple earths, the calcareous, the
barytic, the magnesian, argill, the siliceous, the Scottish, the jargonic,
the adamantine ; but not without intimating a suspicion, that the
four last may be modifications of some of the five first.
    In addition to the *chemical characters* which he before employed alone
in his arrangement of stones, he has now adopted from the illustrious
Werner, the use also of the *external physical characters*, indicated by
that naturalist.
                                                            The

The *external characters* which Kirwan here employs, are, *colour, shape, lustre, transparency, texture, cohesion, density, adhesion* to the tongue or fingers, and general *feel, colour of a streak, absorption or diffusion* in water, *smell,* and *taste.*

The *internal characters, are, relation to acids, changes operated in a low heat, fusibility and* other changes in higher degrees of heat, *phosphorescence, magnetism, electricity,* and the results of a just analysis.

He gives very ample tables of the fusibility of the simple earths, mixed in various proportions, in heats not exceeding 166°. of Wedgewood's pyrometer.

His primary genera consist of earths and stones having an HOMOGE-NEOUS aspect.

The species of the *calcareous genus,* are now augmented to the number of *thirteen,* and are all considerably altered in the descriptions of them, and in their arrangement in the table.

The species of the *barytic genus* are now reduced to *three*; barolite or aërated barytes; barytes combined with the vitriolic acid; and the liver-stone, or *lapis hepaticus.*

The species of the *magnesian,* or *muriatic genus,* are now increased to *twenty.*

The *argillaceous genus* is divided into *two classes*; *the first* comprehending argillaceous earths liable to moulder in water, and subdivided, not into species, but into *six tribes*; *the second* containing argillaceous stones not liable to moulder in water, and subdivided into *seventeen species.*

The species of the *siliceous genus* are now augmented to *forty-four.*

The *strontian* or *Scottish genus* consists of but *a single* species.

The *jargonic genus* has no species, save only the jargon of Ceylon.

The *Sydneian* is not more diversified than the two last foregoing genera.

The *adamantine genus* has but the single species of adamantine spar, diversified into three varieties.

From the discrimination and history of these homogeneous earths and stones; Mr Kirwan next proceeds to examine AGGREGATED *stones*; which he defines to be " stones visibly involving two or more hetero-" genous substances, either adhering together, or inhering one in the " other." Of this character, he enumerates and describes granite, sienite, granatine, granitell, granilite, gneifs, shistose mica; porphyry, jasper porphyry, hornstone porphyry, pitchstone porphyry, obsidian porphyry, horn porphyry, petunse, petunse porphyry, clay porphyry, hornblende porphyry, trap porphyry, wacken porphyry, mullen porphyry, kragg porphyry, argillitic porphyry, novaculite porphyry, pitstone porphyry, serpentine porphyry, granite porphyry. sandstone porphyry, amygdaloid, pudding-stone; calcareous sandstone, argillaceous
<div align="right">sandstones</div>

fandſtones, filiceous fandſtones, ferruginous fandſtones, rubleſtone, bre-
cias.

After thefe follow the *derivatives*, which are defined as " feeming
" to participate of the nature of two or perhaps more heterogenous
" foffils, without, however, any vifible feparation of one from the other."

In thefe appendices, Mr Kirwan, examines, 1. diamond, and 2. volca-
nic products ; and 3 gives an account of the chemical analyfis of earths
and ſtones.

The fecond volume of this valuable work, in which the author pre-
mifes to treat of faline inflammable and metallic fuftances, is impatiently
expected by the public—H.

C H A P.

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CHAP. IV.

Of the Chemical Analysis of Earths and Stones.

THOUGH, within thefe few years, the chemical
analyfis of earths and ftones has been much more
iduftrioufly profecuted than at any former period, yet
ill it muft be confeffed, that our knowledge of their
omponent principles is far from being fufficiently ex-
enfive or accurate, to be affumed as the foundation of
methodical arrangement of them. Hence the diver-
ty of the chemical claffifications of thefe fubftances
which have been hitherto offered to the public; and
or this reafon have we been induced to give an account
if the different methods fucceffively propofed by three
celebrated chemifts in the courfe of a very fhort period
of time.

The chief advantage which has been gained from
the various refearches of late made into the nature and
component principles of earths and ftones, is the difco-
very of proper means for diftinguifhing thefe. The
method of analyfing thefe fubftances is not a little
complex; and I mean to give only a general account
it in this chapter. In fact, as the ftudent of che-
iftry, who has read only the foregoing part of this
work, though acquainted in fome degree with the
phenomena of fire, air, and water, muft be entirely

ignorant of the properties of ſaline bodies, which
are ſo efficaciouſly employed in ſeparating and exa-
mining the conſtituent principles of earths and ſtones ;
if we were here to ſpeak of the uſe of ſolvents in ana-
lyſing theſe matters, we ſhould both deviate from that
order and regularity which are neceſſary in laying
down the elements of phyſical ſcience, and likewiſe run
the riſk of becoming unintelligible : I ſhall therefore re-
ſerve a minute and particular account of the chemical
decompoſition of earths and ſtones by acids and alkalis
to a different part of the work *, explaining here no-
thing but its general principles.

When we wiſh to diſcover the chemical properties
of a ſtone or an earth, we muſt begin with a careful
examination of its phyſical properties, its form, hard-
neſs, gravity, colour, &c.   The extraneous ſubſtances,
of which there is always a greater or a leſs quantity
mixed with ſuch bodies, muſt next be ſeparated from
it, ſo as that it may be purified from all mixture, by
picking, waſhing, &c.   A ſtone ſhould be reduced to
powder, or, if the expreſſion may be allowed to the
ſtate of earth, before we attempt to examine its prin-
ciples.   The firſt trial that is made is generally with
fire.   A few ounces are expoſed in a well-baked cru-
cible of clay or porcelain, to the heat of a ſtrong fur-
nace, ſuch as Macquer's ; that of a potter's or a glaſs-
maker's is ſtill better for the purpoſe.   It is to be ob-
ſerved of the crucibles uſed in this operation, that the
argillaceous earth of which they are chiefly compoſed
                                                    has

* See the treatiſe on the *Analyſis of Waters*, at the end of this work.
—F.

has often a confiderable fhare in producing the altera-
tion which the ftony fubftance feems to fuffer from heat :
but we have no way of avoiding this inconvenience;
and indeed it becomes of little confequence in a com-
parative analyfis of a great number of ftones. Of late
years, the ufe of the blow-pipe for treating mineral
matters with fire, has been introduced; and in the
chemical examination of an earth or a ftone, this in-
ftrument may be employed together with the above
defcribed means for decompofition. Thofe fubftances
are expofed to the fire, either alone or feveral of them
mixed together, or with a mixture of fome faline mat-
ters to be afterwards defcribed *. Laftly, they may
be likewife treated · with a machine for pouring vital
air on coals, of which I have given a defcription in my
Memoirs de Chimie, and which produces a heat that
for intenfity may be compared to the focus of a glafs
lens, fuch as that of the academy. Thefe operations
produce either a fufion more or lefs perfect, or fome
change of colour, confiftency, form, &c. which is to
be carefully defcribed. The procefs muft be farther
carried on, by putting the ftony matter into an earthen
retort, fitted up with a receiver and a pneumato-che-
mical apparatus †, in order to collect whatever water
and aëriform fluids may be difengaged. Matters which
afford thefe products are properly falino-terrene fubftan-
ces, though they be confidered as ftones by naturalifts;

<div align="right">yet,</div>

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* See Bergman's paper on the blow-pipe, with Mongez's notes
Manuel de Mineralogifte; or Cullen's Englifh tranflation of Berg-
man.—F.—H.

† See a defcription of this apparatus under the article *Gaz* of the
Chemical Dictionary, or in M. Sigaud d ˙   on the diffe-

yet,· as they are often found mixed with genuine earths, it is therefore proper to mention here the gene-ral mode of examining them. The action of fire fhows whether a ftone be filiceous, aluminous, or mixed. But as moft ftones are of the latter kind, and many of them confift of feveral, fome even of five or fix, diffe-rent fubftances united in various proportions, other. proceffes are likewife·to be employed for determining the principles of their compofition. Thefe confift in treating them with feveral acid and alkaline folvents, the fucceffive application of which feparates all the principles of which they confift.

The action of air, and of water in vapour, may like-wife contribute to make us underftand the ·nature and conftituent parts of earthy and ftony matters. Some of them fuffer no alteration from thefe agents; others are divided, and gradually affume a new form, colour, and confiftency. Thefe phenomena belong chiefly to ftones of a very compound nature, and containing much iron. Laftly, lixiviation with cold and warm water, fhows whether they contain faline matters, however difficult it may be found to bring thefe to folution.

Such are the means by the ufe of which modern chemifts have been able to determine the nature and the component principles of fo great a number of earths and ftones. I have here given but a very fhort and general account of them. In the hiftory of faline mat-ters, we fhall give all thofe particulars concerning them which cannot be conveniently or advantageoufly introduced here.

SECTION

SECTION II.

CHAP. I.

*Saline Subflances in general; their Characteriflics,
Nature, and the Method of arranging them.*

ALINE fubftances, of which there are a very con-
fiderable number, poffefs peculiar properties by
ſich they are diftinguifhed from thoſe which we have
herto been examining. The properties which have
en employed by *chemiſts* as characteriftics of faline
itters, are fuch as leave their real nature fomewhat
certain : being common to many other bodies be-
e falts, they extend this claſs of fubftances far be-
nd its juft limits. Tafte and folubility in water,
ſich have been always given as characteriftics of fa-
e fubftances, belong to many bodies which are not
ine; as for inftance, to all mucilages and animal
.tters. Theſe two properties again exift in a very
ɤ and imperfect degree in feveral faline fubftances.
ituraliſts have not been more accurate in their defi-
ions of falts : the tranfparency and cryftalline form
ich many naturalifts have confidered as peculiar to
:m, belong equally to many other matters, efpeci-
ɤ earths, while fome falts are quite deftitute of them.

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Macquer has, therefore, aſſerted, with great truth, that the true limits which divide ſaline matters from other claſſes of ſubſtances are not well known.

Yet as we *muſt* take *ſome* ſide, and form ſome determinate notions concerning the properties of theſe matters, we ſhall take a general view of them, before proceeding to the hiſtory of each particular ſalt.

We acknowledge as ſaline ſubſtances, all ſuch as poſſeſs the greater part of the four following properties: 1. A ſtrong tendency to combination, or affinity of compoſition: 2. A ſtronger or fainter taſte: 3. A greater or a leſs tendency to ſolution: 4. Abſolute incombuſtibility. Before proceeding to confider each of theſe properties by itſelf, we muſt obſerve, that in proportion as a body contains more or fewer of them, and thoſe in a greater or leſs degree, it is more or leſs of a ſaline nature. From this, however, we muſt not conclude, that matters poſſeſſing theſe properties but in a very faint degree are not ſaline. Were we to admit ſuch a principle, we ſhould expoſe ourſelves to frequent errors; as it ſometimes happens that two ſalts, which in a ſolitary ſtate poſſeſſed theſe properties in a very low degree, afford ſtill fainter indications of them after being combined. In ſuch caſes recourſe muſt be had to chemical analyſis, which, by ſeparating the ſubſtances, will render their chemical properties more obſervable.

§ L

I. *Tendency to Combination conſidered as a Characterïſtic property of Salts.*

MOST ſalts have a tendency to combine with many lifferent ſubſtances. Among ſalts we find the moſt &tive bodies in nature, capable of forming an infinite number of combinations, by entering into union with ﬆhers. Chemiſts have, therefore, always made moſt rſe of ſaline matters; ſome of which they have honour-:d with the names of *ſolvents* and *menſtrua.* Yet this ﬆendency to combination is far from being the ſame in Iﬆ ſalts. Some of them poſſeſs it in ſo ﬆrong a degree, ﬆat they corrode and deſtroy, or diſſolve whatever ﬆuches them, even vitrifiable and quartzoſe ſtones not eﬆiſting their attacks; ſuch is the power of many of ﬆoſe pure ſalts that are known by the names of *acids* ﬆd *alkalis.* Others, though not poſſeſſed of ſuch a rce of combination, unite readily with many bodies. ﬆly, there are ſome among them, whoſe tendency to nbination is but very trifling, and ſcarce ſuperior to t of earthy matters. But the cauſe why, in theſe lat-the tendency to combination is ſo ſmall, ﬆs, their ﬆg in a great meaſure ſaturated, as is obſervable of : neutral ſalts. After this, we cannot well be ſur-d that ſalts are ſcarce ever found in a pure or ſolita-ﬆe in the bowels of the earth.

I. *Taſte conſidered as a Characteriſtic of Salts.*

Tᴇ has been always regarded as ſo eſſential a ·y of ſaline ſubſtances, that many philoſoph

have conſidered them as the only bodies in nature poſ-
ſeſſed of this property, and the principle of all taſte.
Though this opinion be not demonſtratively certain,
as there are many bodies, ſuch as metals, which have a
diſcernible taſte, though not ſaline, while, again, ſeve-
ral ſaline ſubſtances have ſcarce any taſte ; yet it muſt
be acknowledged, that moſt ſalts poſſeſs the property
of taſte ; and this property is therefore to be conſidered
as one of their leading characteriſtics. The taſte of
ſalts, like their other properties, is different in different
ſpecies. In order to underſtand aright on what circum-
ſtances it depends, and whence the cauſes of its varie-
ties, we muſt firſt endeavour to diſtinguiſh what conſti-
tutes the peculiar nature of this property. By taſte,
we uſually underſtand an impreſſion made on a certain
organ which nature has given us for the purpoſe of diſ-
tinguiſhing by it ſome material body, and from which
we judge of that body as uſeful or noxious, and deter-
mine either to make uſe of it or reject it. It is there-
fore the action of the ſapid body on the nerves of the
tongue and palate of animals, which informs them that
one ſubſtance may be of uſe, or another hurtful to
them. But can this property of bodies affect only the
nerves of the tongue ? will it not act with equal force
on the whole nervous ſyſtem? Thoſe who are acquainted
with the phenomena of the animal œconomy, know that
the action which conſtitutes taſte or ſapidity, muſt af-
fect all the other nerves, and muſt always be propor-
tioned to the ſenſibility of the ſubjects and the organs
on which it operates. This idea of taſte naturally leads
us to think, 1. That this quality of bodies will make
ſcarcely any impreſſion on ſuch parts of the body as have

bу

but few nerves, or of which the nerves have but little
ſenſibility, on account of their being covered ; as on
the ſkin where they are defended by the reticular mem-
brane and the epidermis. 2. That this quality of bo-
dies will act with the moſt energy on thoſe organs in
which the nerves are largeſt, moſt numerous, and of a
form the moſt proper for receiving an extenſive contact,
and a violent emotion from ſalts ; the epidermis being
ſo thin as to leave the nerves almoſt naked. The ſupe-
rior ſurface of the tongue, the roof of the mouth, and
all the inner part of the mouth in general, are ſuſcep-
tible of the ſenſation of taſte, from a vaſt number of
bodies which make no ſuch impreſſion on the leſs deli-
cate ſenſibility of the other parts of the ſkin. 3. That
bodies which have no taſte and no power of affecting
the ſkin, may notwithſtanding this, act upon organs
which are more delicate, and have nerves of greater
ſenſibility, ſuch as the ſtomach and the inteſtines.

Admitting theſe facts, we may diſtinguiſh taſtes and
ſapid bodies into three claſſes, under which all the
ſaline ſubſtances that we are to examine may be ar-
ranged. The firſt claſs comprehends ſuch ſalts as have
the ſtrongeſt taſte, and affect the ſkin in the moſt ſen-
ſible manner. The impreſſion of theſe ſalts is ſo power-
ful, that it occaſions a very lively ſenſation of pain ;
and where its action is continued for ſome time, it
entirely deſtroys the organization and texture of the
ſkin. This property is called *cauſticity*, and the ſalts
which poſſeſs it are named *cauſtics* The ſecond claſs
conſiſts of ſalts which have a milder taſte, and affect
only the nerves of the organs throu᠎ ᠎h which we receive
that ſenſation : theſe are

ther by names expreſſing the ſeveral impreſſions which
they make on thoſe organs; ſuch as bitterneſs, aſtrin-
gency, acidity, acridity, urinous taſte, &c.   To the
third claſs we ſhall refer ſaline ſubſtances, the taſte of
which is ſenſible only to the ſtomach and the inteſtines;
but the number of theſe ſalts is very ſcanty.

Some obſervations are neceſſary on the mutual rela-
tions of theſe ſeveral claſſes of ſalts.   It is firſt to be ob-
ſerved, that between thoſe which poſſeſs the peculiar
properties of any of the three claſſes in the weakeſt,
and thoſe which poſſeſs the ſame properties in the
ſtrongeſt degree, there are many varieties; there are
ſtronger and weaker cauſtics; ſome inſtantly deſtroy
the texture of organized ſubſtances, others require a
conſiderable time to produce that effect.   The ſame
fact may be obſerved of bitter, aſtringent, or urinous
ſalts, as well as of thoſe which act only on the nerves
of the ſtomach.   Secondly, when we conſider theſe
varieties of the ſeveral claſſes, we are naturally led to
think, that all taſtes are but different degrees of the
ſame property, from that of the ſtrongeſt cauſtic falt to
that of the ſaline ſubſtance, whoſe action is ſcarce ſen-
ſible to the nerves of the ſtomach.   This obſervation
implies, that all taſtes actually depend on the ſame
cauſe, and participate of the ſame principle.

We cannot adopt an happier method of diſtinguiſh-
ing the cauſe of taſte, than to conſider that taſte which
is the ſtrongeſt of all, obſerve its phenomena, and at-
tend to its action.   Cauſticity muſt therefore be the
ſubject of our conſideration: a property which has
always attracted the curioſity of chemiſts.   Lemery, ob-
ſerving that very hot bodies were uſually very cauſtic,
and

and that all falts poffeffing the property of caufticity
have been ftrongly heated before acquiring it, afcribed
this property to the particles of fire lodged in cauftic
bodies. M. Baumé has implicitly adopted, Lemery's
opinion. Meyer, an apothecary of Ofnaburgh, made a
feries of refearches into the nature of cauftic falts, and
formed a very plaufible theory, which was at firft warm-
ly embraced by a number of chemifts, but is no longer
mentioned with the refpect which it once obtained.
He attributed caufticity to a principle which he confi-
dered as a compound of fire and a peculiar acid : this,
in imitation of the ancient chemifts, he named *caufti-
cum*, or *acidum pingue*. He traced it through its various
combinations, as Stahl had done with phlogifton. But
his fyftem has the fame defect with Stahl's ; the exift-
ence of his *caufticum* has not been demonftrated. Dr
Black, by a feries of experiments on the fame matters
which Meyer examined, has levelled the fevereft blow
again *his* theory ; proving, by rigid demonftration, that
lime and alkalis, inftead of deriving their caufticity from
a *fat acid* principle, become acid in confequence of lof-
ing a falt, to be afterwards mentioned under the name
of the *Carbonic Acid.*

Macquer has undeniably been the moft fuccefsful
inquirer into the caufe of caufticity. The doctrine
which he lays down on that article in his Chemical
Dictionary is fo plain, and fupported by fuch conclu-
five facts, that we cannot refufe affenting to his opinion.
After obferving that cauftic bodies deftroy and corrode
our organs, by entering into combination with the
principles of which they are compofed, he remarks,
that in proportion as this combination takes place, the

cauſtic gradually loſes its ſtrength; and that it becomes abſolutely deſtitute of cauſticity, when it has diſſolved as much of the animal matter as its force and quantity are equal to. Thus the *lapis cauſticus*, ·or pure fixed alkali, gnaws and corrodes the ſkin when applied to it; but loſes its corroſive and ſolvent power when it ceaſes to act on that organ. This ſalt really acts by a chemical power, for it exerts its force even on the inſenſible ſkin of a carcaſe; as M. Poulletier has ſhown by accurate experiments, and on all animal ſubſtances in general. Cauſticity therefore depends on tendency to combination; and the ſenſations with which it affects our organs are occaſioned by the combination of the cauſtic with the matter of which the organs are compoſed. In the ſame manner a cauſtic loſes its virtue in the laboratory, by combining with any ſubſtance with which it has a ſtrong affinity; and in a word, the cauſticity of a body is always in the proportion of its tendency to combination. That ſalt which has the fainteſt taſte is already ſaturated with ſome ſubſtance; and by ſeparating it from that ſubſtance, we cauſe it to regain a taſte, ſtronger or weaker, according as the ſeparation is more or leſs complete. The whole hiſtory of ſaline matters concurs to ſupport this opinion, as will appear in what follows.

§ III.   *Solubility conſidered as a Characteriſtic of Salts.*

SOLUBILITY in water has been given by all chemiſts as one of the moſt eminent characteriſtics of ſalts; yet this property, like taſte and tendency to combination, is ſubject to varieties. Some ſalts poſſeſs it in ſuch a

degree,

legree, that without very long and refined proceſſes,
t is impoſſible to ſeparate them entirely from water.
Others are not ſo extremely ſoluble, and the degrees
)f their ſolubility may be preciſely aſcertained ; as, for
inſtance, moſt neutral ſalts. Laſtly, there are ſome ſa-
line ſubſtances, whoſe tendency to ſolution is ſo faint
and indiſtinct, that they ſeem to differ more in nature
from the other claſſes of ſalts than from earths and
ſtones ; and all ſalts of this character have been by
moſt naturaliſts conſidered as earths and ſtones. It is
indeed extremely difficult to fix the preciſe limits be-
tween theſe two claſſes of mineral bodies; and che-
miſts have not as yet agreed in determining them. Mr
Kirwan, in his mineralogy, ſeems to have adopted Berg-
man's opinion ; who thinks that all ſubſtances are to be
:onſidered as earths, which require more than a thou-
and times their own quantity of water to maintain
hem in a ſtate of ſolution, while all ſuch as are ſoluble
ı a ſmaller proportion of water, ſhould be diſtinguiſh-
l as ſalts. Were this propoſition generally received
ıong chemiſts, as I think it well deſerves to be, that
'erſity of opinions and terms which has hitherto pre-
led on this point might be avoided ; and they have
lirect tendency to render the ſcience more obſcure
perplexing to beginners.

'he relation which I have taken notice of, as ſub-
g between the taſte and the ſolubility of ſalts, is
fely the ſame with that which ſubſiſts between taſte
:endency to combination. The cauſe of theſe
ıns may be eaſily underſtood by obſerving, that
ın in water is a real chemical union of a ſalt with
and muſt therefore d

with tafte and tendency to combination. In fact, the more tafte and folvent force a falt has, the more readily does it diffolve in water. This law holds invariably with regard to all faline matters, and even depends on their nature and effential properties.

§ IV.   *Incombuftibility confidered as a Characteriftic of Salts.*

It is more difficult to form a determinate idea of this fourth than of the three preceding characteriftics of faline matters.   No chemift has as yet confidered thefe fubftances under this point of view.   A number have even thought, that fome falts, and among others nitre, are actually combuftible.

In order to fee clearly that this is a miftake, and that all mineral faline fubftances are abfolutely incom- buftible, the ftudent of chemiftry muft have a much fuller knowledge of the properties of thofe fubftances, than he can have acquired from perufing the foregoing part of this work.   However, as we think this one of the moft effential and important characteriftics of falts, we fhall here give a fhort view of the doctrine which we are induced to advance on this head, and which will be fully illuftrated and inconvertibly eftablifhed, in our particular examinations of faline fubftances.

It appears from M. Lavoifier's fine experiments, that many combuftible matters form by their combuftion, peculiar acids. Combuftion, as above explained, is nothing but the combination of the bafe of vital air, or the oxigenous principle with combuftible b Every body which has been completely b

which has been faturated with the oxigenous principle, returns into the clafs of incombuftibles ; or what is juft the fame, its tendency to combine with the oxigenous principle is fatisfied, and it cannot unite with a new quantity of oxigene, or abforb any more of it. This being admitted, it plainly follows, that, as a number of falts are refidues of various combuftible bodies, and even an entire clafs of faline fubftances are found to have oxigene for one of their principles, and exhibit the charaćteriftics of fubftances which have been expofed to combuftion; thefe cannot be any longer fufceptible of combuftion. A numerous train of faćts, which fhall be hereafter related, concur to juftify thefe affertions : they prove falts to be compound bodies, moft of them formed by the union of certain combuftible bodies with the oxigenous principle. From this it is eafy to underftand that incombuftibility deferves to be regarded as one of the moft certain and invariable charaćteriftics of faline matters. We hope that this will be completely demonftrated of the clafs of acid falts, when we come to enter particularly into the hiftory of thofe fubftances.

Yet there is one clafs of falts which, though evidently compound bodies, are not known to contain any portion of the oxigenous principle : all the alkalis are of this clafs. But thefe are either compounds of incombuftible bodies, or if fome combuftible matter enter into their compofition, as we fhall have occafion to obferve of ammoniac or volatile alkali, it is united with fome fubftance evidently incombuftible, which hinders the combuftibilitv of the other matter from being ob-
ferved.

§ V.   *Of the general Nature and Compoſition of Saline*
                        Matters.

STAHL, after ſtudying the nature of ſalts with much
attention,   was perſuaded that they were generally
formed of earth and water.   He collected all that che-
mical reſearches could ſupply to ſupport and illuſtrate
his theory.   But ſince that illuſtrious æra of chemical
ſcience has been ſucceeded by one ſtill more illuſtrious,
for both the multiplicity of the reſearches proſecuted,
and the importance of the diſcoveries which theſe have
produced ; Stahl's theory, which is very perſpicuouſly
explained in the works of Macquer, is no longer ſuffici-
ent to explain the nature and compoſition of ſalts. We
are no longer content with thoſe remote analogies which
forced the moſt diſcordant facts into an unnatural uni-
on, and bewildered the underſtanding by exhibiting to
it illuſive lights.   Philoſophers now chooſe rather to
confeſs their ignorance,   than to advance ill-found-
ed theories, which may ſooner or later be refuted by ex-
periments.

Although the chemical nature of ſalts be not yet en-
tirely known, and facts allow us not to agree with ſome
of the moſt eminent philoſophers, in acknowledging one
ſaline principle as the baſe and element of all ſalts;
yet the component principles of this ſingular and nu-
merous claſs of ſubſtances, are ſomewhat better known
now than formerly.   We know that mo   on-
tain a very conſiderable quantity of **the**
ciple ; which principle is fixed in
matter.   This has fully

tion of a number of acids ; and we have the ſtrongeſt
reaſon from analogy to conclude, that moſt other ſalts
of that claſs have the ſame character. Water, though
not one of the. immediate principles of ſalts, is often
found united to them, and has a ſtrong affinity with
them. As to the matter of fire conſidered as phlogiſ-
ton, which ſome of the moſt eminent chemiſts have ad-
mitted as a component principle in ſalts, the nature and
exiſtence of that matter are too uncertain to admit of
our adopting any determinate opinion in reſpect to it.
The caſe is not the ſame with the caloric principle; it
ſeems evidently to conſtitute one of their component
principles; in ſome however, it exiſts in a much ſmal-
ler proportion than in the reſt, which appear in general
to owe to it their fludity, fuſibility, and volatility. The
exiſtence of earth in·any conſiderable number of ſalts
has never been experimentally demonſtrated. We know
only that all the ſaline bodies which nature exhibits,
are mixed with a larger or a ſmaller quantity of various
earthy ſubſtances. But theſe, properly ſpeaking, do not
belong to them; they form no part of their compoſition,
and may be ſaid to be only acceſſories. The only ſub-
ſtances at preſent acknowledged as general principles
of ſaline matters, are ſeveral combuſtible bodies, the
oxigenous principle, a few incombuſtible matters, and
the caloric principle. It is well known that moſt acids
are reſidues of burnt bodies, and contain oxigene and
combuſtible matter combined together in various pro-
portions. Whatever more has been advanced in trea-
ting the nature of ſalts, is no-
us hypotheſis, unſuppor-

§ VI.

§ VI. *Of the Diviſion and Arrangement of Mineral
Saline Matters.*

Thᴇ ſalts belonging to the mineral kingdom are very
numerous. A number of them are products of nature,
formed by the action of fire, water, and air, and by
the diſſolution of organic matters. But moſt of thoſe
which are employed in chemiſtry owe their formation
to art, or at leaſt have not hitherto been found among
the products of nature. In order to give a methodical
view of the hiſtory of theſe ſubſtances, we ſhall divide
them in the ſame manner as ſtones, into orders, gene-
ra, and ſpecies. All ſaline matters may be arranged
under two orders.

The firſt contains thoſe ſaline ſubſtances which have
been named *ſimple*, and which we ſhall diſtinguiſh by
the name *primary ſalts*, becauſe they ſerve as princi-
ples to thoſe of the ſecond order.

The ſecond conſiſts of the ſecondary, compound, or
neutral ſalts. Theſe are formed by the combination of
two or more of the former order, and are of conſequence
much leſs ſimple than they.

Each of theſe orders ſhall be divided into ſeveral ge-
nera, and theſe again into ſpecies.

Nine genera, and eighty-ſix ſpecies of ſimple and
compound ſalts together, are at preſent known to exiſt
in the mineral kingdom; and theſe we ſhall ſucceſſive-
ly examine *.

* There are three ſalino-terrene ſubſtances, three alkalis, and ten mi-
neral acids. Theſe laſt, united with aluminous earth, with the three
ſalino-terrene baſes, and with the three alkalis, compoſe 70 compound
or neutral ſalts.—F.

C H A P.

CHAP. II.

Of the three Salino-Terrene Substances *.

ORDER I. SIMPLE *or* PRIMARY SALTS.

WE give the name of *simple* or *primary salts* to those matters which were formerly known by the name of *simple salts*, and are still so called by some chemists. As it has been shown, by fair experiments, that most of them are really compounds, therefore the title of simple salts cannot with any propriety be applied to them, except when they are compared with the salts of the second order. The name of *primary salt*, seems the most suitable for distinguishing them, because they form by combination those neutral or compound salts which we call *secondary*. We shall divide this order into three genera, salino-terrene substances, alkalis, and acids. The examination of the first will occupy this chapter; in the two following we shall give the history of alkalis and acids.

3   Genus

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* The title of this chapter is the general denomination of the first genus of the first order of simple or primary saline matters.—F.

Genus I.   *Salino-Terrene Subflances.*

By this name we denote three fubftances which have
been hitherto regarded as earthy matters, but whofe
properties plainly fhow them to be more properly fa-
line *.   As thefe fubftances poffefs the diftinguifhing
properties of falts, in conjunction with the characterif-
tics of earthy matters, yet, difplaying the latter in a
lefs eminent degree ; we therefore rank them before
the falts, ufing them as a link of connection between
falts and earths : They differ alfo from earths as having
a ftronger tendency than thefe to combination, as will
appear from an examination of their properties.

It is proper to obferve, that in our examination of
thefe falino-terrene matters, as well as in our account
of the primary falts, we fuppofe them pure and folitary,
though they be never found fo in nature ; and we avoid
mentioning the methods by which they are obtained,
from a defire not to break through that elementary or-
der which we have determined to follow through the
courfe of the work.   When we come, in the hiftory of
neutral falts, to give an account of their decompofition,
we fhall then have occafion to defcribe the methods by
which chemiftry feparates thofe fubftances, as well as
the fimple or primary falts, fo as to afford them
pure.

This firft genus contains three fpecies of falino-ter-
rene bodies.

                                                          Species

* We have already given fome account of them in lithology ; but
then only as making a part of natural hiftory.—E.

Species I. *Barytes.*

THE firſt name of this ſubſtance was *ponderous earth*; given it by the Swediſh chemiſts Gahn and Scheele, who diſcovered it in ponderous ſpar: Bergman and Mr Kirwan have already given it the Latin name *barytes.* Its ſpecific gravity, according to Mr Kirwan, is ſomething more than 4,000. Nature no where affords this earth in a pure but always in a combined ſtate. It was firſt diſcovered and diſtinguiſhed as a peculiar earth by the chemiſts above-mentioned. Meſſrs Margraff and Monnet had obſerved it, but confounded it with abſorbent or calcareous earth. Yet the laſt of theſe chemiſts had obſerved it to poſſeſs ſome peculiar properties, and ſuſpected it to be an earth different in its nature from lime. Its properties, in a pure ſolitary ſtate have not as yet been very accurately examined; its combinations have been more ſtudied; and what moſt eminently diſtinguiſhes it from other analogous ſubſtances, is, its very ſingular affinities, and the ſalts which it forms by combination with acids.

Pure barytes, obtained by means which ſhall be afterwards deſcribed, appears under a pulverulent form, very fine and white. I have never found it to affect the tongue with any diſcernible taſte.

It is not yet known whether this ſubſtance be liable to alteration from light.

The ordinary fire of our furnaces does not reduce it to fuſion: But if heated in a clay crucible, it communicates a blue or greeniſh colour to the crucible, and aſſumes itſelf a ſlight tinge of the ſame. This pheno-

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menon ſeems to ariſe from its power of re-action on clay. M. D'Arcet ſays that it melts when expoſed to a very violent heat in a clay or iron crucible *.

When expoſed to the air, it acquires an acceſſion of weight, and combines, though very ſlowly, with the carbonic acid contained in the atmoſphere : the effects of vital air upon it are unknown. We are equally ig-norant of the manner in which the oxigenous and the azotic principles, act upon this ſaline earth. Azote is perhaps one of its conſtituent principles.

Its diſſolves in water, but not without difficulty ; for 900 parts of that fluid are requiſite to diſſolve one of barytes. Water thus ſaturated gives a pale green co-lour to the tincture of violets †, and ſtill more readily to that of mallows or raddiſhes. This ſolution, when expoſed to the air, is covered with a thin pellicle; and if it be ſtripped of this, a new one is produced. This phenomenon is owing to the carbonic acid in the atmo-ſphere : the ſame thing happens to lime-water, though in a leſs eminent degree. The ſolution, when evapo-rated in cloſe veſſels, leaves a reſidue of barytes; and the weight of the reſidue affords a proof of the ſolubility of that ſubſtance. It is almoſt unneceſſary to obſerve, that

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* This is confirmed by the experiments of M. Lavoiſier, who fuſed barytes in a few ſeconds, with a flame fed with oxigenous gas. But this barytes appears to have been in ſome degree impure.—H.

† By tincture of violets, we mean a ſolution of the colouring part of violet flowers in water. This tincture when newly made is prefera-ble to the ſyrup of violets, as being much eaſier affected. But the ſy-rup may be employed in all inſtances in which the ſaline matters under examination act with a determinate energy; and we ſhall therefore of-ten mention it inſtead of the tincture.—F.

n this, as in all other proceffes of the fame nature, di-
ftilled water is to be ufed.

Barytes acts but very feebly, either in the humid
or the dry way, on filiceous and aluminous earth *.
Yet it facilitates the fufion of thofe earths, and affumes
a blue or greenifh colour when heated with the latter
of them. Barytes is lefs copious in nature than either
of the other two falino-terrene fubftances; but it is pro-
bably more copious than it is thought to be. Former-
y, it was not known to exift in any body but barytic
fulfate or ponderous fpar; it was fome time fince found
in England, combined with the carbonic acid, and cry-
ftallifed like a tranfparent fpar. That falt will be af-
terwards defcribed. Some modern chemifts think it to
be a metallic calx or oxide. Its weight, that of the
compounds into which it enters, and the precipitate
which it affords, when a folution of it with an acid is
mixed with an alkaline prufliates, made Bergman long
fufpect it to be of this nature. We are told, that M.
Gahn, a pupil of that celebrated chemift, has actually
obtained barytes under a metallic form; but this fact
needs confirmation. Its nature therefore is ftill un-
known; becaufe we have never yet been able to fepa-

X 2   rate

* We muft here obferve, that in order to give a regular account of
the reciprocal action of bodies on each other, no combination of any
two bodies is mentioned till after thofe two have been defcribed. Thus
in the hiftory of barytes, I have mentioned only the manner in which it
is affected by light, by the caloric, the oxigenous, and the azotic prin-
ciples, by water, and by filiceous and aluminous earth, becaufe none
but thefe have as yet been defcribed. As we advance in the hiftory of
natural fubftances, we fhall learn all the combinations of which it is
ufceptible. Thus we fhall both preferve our order inviolate, and com-
municate all the neceffary information concerning the matters of
which we treat.—F.

rate its principles, or imitate its compofition. I fufpeƈt, as I have already hinted, that the azotic principle, or the bafe of gas azote, is one of its component parts.

Pure barytes is not applied to any ufe; folutions of it in water and in acids are ufed as re-agents, as we fhall elfewhere have occafion to obferve.

Species II. *Magnefia.*

THAT magnefia which is obtained from Epfom falt, or fulfate of magnefia, and which is likewife found in mother water of nitre, and in a great many ftones, &c. is no where in nature to be met with in a ftate of purity, but always combined with acids. Dr Black is the firft chemift who has accurately determined the diftinction between it and lime.

This fubftance, which is obtained by methods to be afterwards defcribed, appears under the form of a very fine white powder, refembling meal both in appearance and to the touch. Its gravity, according to Kirwan, is about 2.33. It has no tafte fenfible to the tongue; but it affeƈts the ftomach as a gentle purgative. It communicates a pale green to the tinƈture of violets and mallows, and caufes turnfol to affume a blue colour. The manner in which light affeƈts magnefia is not well known : it cannot be very powerfully.

According to the experiments of M. D'Arcet, this fubftance does not melt when expofed to a ftrong heat. Macquer too obferved, that it remained unaltered in the focus of the burning lens of the garden *De l'Infante.* M. Morveau heated magnefia for two hours in the ftrongeft fire that can be procured in Macquer's fur-

nace

pace, with the fame effect. M. Butini, a citizen of
Geneva, who has publifhed fome valuable experiments
on magnefia, has obferved, that violent ignition con-
tracts and condenfes magnefia in fuch a manner as to
render it capable of attacking and coroding an iron
furface. We are informed that a fmall cube formed of
a pafte of magnefia and water, and expofed to the focus
of Parker's lens, was fuddenly contracted in all its di-
menfions. This property feems to indicate a relation
between magnefia and aluminous earth; which two
fubftances are often found together in nature, as was ob-
ferved in the hiftory of fteatites, afbeftos, and ferpen-
tines, &c.

Magnefia, though heated in a retort, lofes not the
portion of water which it contains: but when fubjected
to this procefs, it acquires a very difcernible phofphoric
quality, as has been obferved by M. Tingry, apotheca-
ry at Geneva. It fuffers no alteration from air, till af-
ter being long expofed to it. M. Butini kept ten grains
of calcined magnefia in a porcelain faucer covered with
paper, in a dry room, for near two years; the only
change which it fuffered was by gaining one-eighth of
a grain of additional weight. It appears that this fub-
ftance combines flowly with the carbonic acid diffufed
through the atmofphere.

It diffolves in water but imperfectly and with great
difficulty. Four ounces and two drams of pure water,
after ftanding three months in a bottle, with a dram of
calcined magnefia, and being boiled together with that
fubftance, afforded M. Butini, by evaporation, a refidue
which he eftimated at one-fourth of of a grain.

X 3 Mr

Mr Kirwan fays, that 7900 times its own weight of water is neceffary to diffolve it in the ordinary temperature of the atmofphere; that is to fay, at about 60° of Fahrenheit's thermometer. Notwithftanding this averfion to folution, magnefia forms a kind of pafte with water; that pafte indeed is not ductile, but brittle; and the water is readily feparated from it by the action of fire, or even of the dry atmofphere. A folution of magnefia has no fenfible tafte; and it produces but a very trifling alteration on the colour of fyrup of violets.

We are not yet well acquainted with the manner in which magnefia acts on pure earths. We know, however, that it does not vitrify with either filiceous or aluminous earth feparately; but when heated with both together, it is fufceptible of fufion.

Its action on barytes has not yet been examined.

The intimate nature of magnefia is not better known than that of barytes. It has never been fhown by experiment to be a modification of fome other faline fubftance, as fome chemifts have imagined it to be; for magnefia has not yet been either feparated into principles by analyfis, or imitated by a fynthetic procefs. In the prefent ftate of chemiftry, therefore, it is to be confidered as a fimple fubftance.

Pure magnefia, which Dr Black calls *cauftic*, is ufed in medicine as an abforbent and purgative. For heartburnings and other complaints occafioned by acidity, it is preferable to common magnefia: becaufe the carbonic acid which this laft contains is difengaged in the primary paffages by the acids, and produces flatulencies, with all that train of complaints which

pany them : it preſerves fleſh for a long time, and even reſtores putrefied bile. Bergman aſcribes to it like-wiſe the property of rendering camphor, opium, reſins, and gum-reſins, ſoluble in water, and of forming ſome valuable dyes; though cauſtic magneſia be ſcare ſo-luble in water. Theſe preparations are unknown in France *.

Species III. *Lime.*

QUICKLIME is a white ſubſtance, of more conſiſtency than the two preceding matters : it appears in the form of a grey white ſtone. Its taſte is hot, acrid, and u-rinous; it poſſeſſes this property in ſo conſiderable a degree as to inflame the ſkin when applied to it. Its ſpecific gravity is about 2.3; its form pulverulent and friable; it is found in places adjacent to volcanoes; as M. Monnet has obſerved on the hills of Auvergne.

Lime turns ſyrup of violets green, giving it a much more intenſe colour than it acquires from either ba-rytes or magneſia : indeed, it almoſt deſtroys the ori-ginal colour, and in a ſhort time produces in its ſtead a dirty yellow.

Lime, when expoſed to a ſtrong fire, ſuch as that of a glaſs-houſe, remains unaltered; and, in a ſolitary ſtate, it is not ſuſceptible of fuſion. Parker's burning-glaſs appears to have brought it to the beginning of fuſion ; but the lime was placed on a ſupport of charcoal. When heated in a clay crucible, its edges ſometimes ap-

X 4   pear

* We learn from Monget, thᵃᵗ ʰᵉʳᵉ ᶜ ſᵈᵃ. ᵃⁿᵈ phoſphate of urine diſſolve magneſia wi ˉ

pear to melt; but this phenomenon is occaſioned by its acting on the earth of the crucible.

When expoſed to the action of the air, lime ſwells, breaks, and falls into powder; it then increaſes greatly in bulk, and is called *lime flaked in the air*. Theſe phenomena are more remarkable, and take place more rapidly when the air is in a humid ſtate. This dry flaking produces heat; and the dilatation is ſo conſiderable as to burſt caſks, or other wooden veſſels in which lime may be contained. After being flaked with air, this ſubſtance appears under the form of a very fine white duſt; it has acquired a very conſiderable increaſe of weight, and its taſte is become much fainter. Theſe phenomena are occaſioned chiefly by the water contained in the atmoſphere, and the force with which the lime tends to unite with it. And by heating lime which has been flaked with air in a retort, till it becomes redhot, water is obtained, and the lime returns to its original ſtate.

Water acts very powerfully on quicklime. Pour a ſmall quantity of that fluid on a quantity of lime, the water is inſtantly abſorbed; and the maſs of lime appears as dry as before; but it ſoon burſts and breaks into pieces. The heat excited in it by this operation is ſo ſtrong, as to produce a remarkable hiſſing noiſe: the water is reduced to vapour of a peculiar ſmell, which communicates a green colour to paper tinged with mallows. The lime ſoon falls down to a powder; and the heat, motion, and ſmoke, gradually diſappear. If the proceſs be performed at night, in a place pe dark, a great many luminous points are (over the ſurface of the lime. All the

pend on the activity with which this ſalino-terrene
ſubſtance unites with water. But, in order to produce
them, we muſt employ but a very ſmall portion of the
fluid; only ſo much as the lime can abſord without ap-
pearing wet. It appears that the heat diſengaged from
theſe two bodies, when they combine with ſuch rapi-
dity, changes their ſtate; and that the lime, when
flaked, and reduced to a ſtate of pulverization, contains
water in a dry and ſolid form. This dry ſtate of water
—which takes place in many of the combinations in
which heat performs a part, and produces ſolid com-
pounds, whoſe ſpecific heat is leſs than that of the bo-
dies of which they are formed,—has not yet ſufficient-
ly engaged the attention of chemiſts; indeed it has been
but lately obſerved. When lime has abſorbed as much
water as it can contain, without becoming wet, it is
then called *dry flaked lime;* water no longer excites any
heat in it, and only diſſolves it, without producing any
very diſcernible motion. By mixing lime with a proper
quantity of water, we obtain milk of lime; and by add-
ing ſo much water as may be neceſſary to effect a com-
plete ſolution of this ſalino-terrenous matter, we produce
a liquor perfectly tranſparent. Mr Kirwan ſays, that
about 680 times its weight of water is neceſſary to
maintain it in ſolution at the temperature of 60°.

This ſolution, which is known by the name of *lime-
water,* is clear and limpid. It is but very little heavier
than common water, has an acrid urinous taſte, com-
municates a deep green to ſyrup of violets, and even
produces upon it an entire alteration of colour. Lime-
water, when evaporated in cloſe veſſels, affords very
pure water, leaving a reſidue of quick-lime at the bot-

tom of the veſſels : But this reſidue needs to be very ſtrongly heated, in order to ſeparate entirely the water which ſtill adheres to it. After which this fluid excites heat in it, in the ſame manner as before its ſolution.

Lime-water, when expoſed to the air, is covered with a dry pellicle, which becomes gradually thicker and more ſolid. If the firſt pellicle be taken off, a ſecond is formed, and this proceſs may be repeated till all the water be evaporated. Theſe pellicles have been improperly termed *cream of lime.* This was formerly thought to be a peculiar ſalt, formed by the union of the fineſt calcareous earth with water ; and much has been written concerning this pretended ſalt of lime. But it is now well known from the experiments of the celebrated Black, that the cream of lime poſſeſſes ſaline properties leſs active than thoſe of lime, and that it is a peculiar neutral ſalt formed by the combination of lime, with a certain acid contained in the atmoſphere ; and the cream is never formed on lime-water, except when it is expoſed to the air. We ſhall elſewhere examine this ſalt under the name of *carbonate of lime or chalk.* The manner in which the oxigenous and the a-zotic principles affect lime is not yet known : it is probable that this baſe abſorbs and fixes ſome part of gas a-zote, and at leaſt contains the baſe of this gas.

Lime combines with ſiliceous earth in both the humid and the dry way. If ſand be mixed with lime newly flaked, or with quick-lime ſprinkled with a ſmall quantity of water at the time of mixing, the two bodies become conſiſtent, and form what is called *mortar.* This mix-ture is liable to many varieties ; from the ſtate and quantity of the quick-lime, the quantity of water with

which

which it has been flaked, the circumftance of the fand
being mixed with it at the inftant of its flaking, or not
till fome time afterwards; and from the fize, the
roundnefs, the inequality, the moifture, or drynefs of
the fand *. Mortar is alfo compofed with clay baked
for bricks, and with puzzolana, which is nothing but
clay baked by volcanic fire, and altered by the contact
of the air.

Though lime, as well as filiceous earth, be abfolutely
infufible by itfelf; yet if thefe two fubftances be heat-
ed together, the former in a greater proportion than
the latter, they are fufceptible of fufion, as has been
obferved by Meffrs d'Arcet and Gerhard. Lime like-
wife melts with a quantity of aluminous earth equal to
one-third of its own weight; and Mr Kirwan fhows,
that it has a greater affinity with this than with filice-
ous earth. A mixture of all the three fubftances melts
eafier and more completely than a mixture of lime
with any one of the other two. Thus one part of lime
and one of alumine will occafion the fufion of two parts,
or even of two and an half of filice. From this fact we
underftand why fo many ftones, apparently hard, fcin-
tillating, and quartzofe, melt notwithftanding, when
expofed to a ftrong fire. The combination, or even the
mixture of calcareous earth and clay, with filiceous
earth, occafions this phenomenon.

It is not yet known in what manner lime acts on ba-
rytes.

One part of calcareous earth produces the fufion of one
half

* See Recherches par M. de la Faye, fur la preparation que les
Romains donnoient à la chaux, Paris 1777-8. = ==-
tie.—F.

half part of magneſia. The glaſs formed by this mix-
ture, in fire completely diſſolves and reduces to fuſion a
quantity of ſiliceous earth equal to the quantity of the
lime. Accordingly, equal parts of magneſia, lime, and
ſilice, when expoſed to fire together, afford a perfect
glaſs.

The intimate nature of lime is unknown. The firſt
chemiſts who attempted to explain by phyſical reaſon-
ings the phenomena which lime diſplays in its combi-
nations, and eſpecially when flaked, aſcribed them to
the fixation of particles of fire in the calcareous ſtone
during its calcination. Such was Lemery's theory.
Meyer was of opinion that pure fire was not fuſceptible
of ſuch a combination, and that there was a peculiar
acid which combined with it in the lime. This ſubtle
kind of ſulphur was the *acidum pingue,* or *cauſticum* of
that chemiſt. But this doctrine, which has ſince been
repeatedly offered to the world under different names,
is overthrown by a ſeries of experiments clearly de-
monſtrating its falſity. Many modern chemiſts think,
that the matter of heat is combined in lime ; and that
by its diſengagement during the flaking of this ſub-
ſtance, the light obſerved by Meyer and M. Pelletier,
the ebullition and the evaporation of the water, as well
as the peculiar fetid odour exhaled on the occaſion, are
produced. It appears, however, from what has been
ſaid, that the principles and compoſition of lime are
ſtill unknown. Some very diſtinguiſhed naturaliſts
have thought it to be in all probability a certain pre-
paration of ſiliceous or aluminous earth effected by the
organs of animals; but this is by no means certain. It
is ſurely, however, formed by marine animals; its con-
ſtituent

ftituent parts are certainly united and combined under water during the life of thofe organic beings; and azote is certainly *one* of its conftituent parts: yet all this is infufficient to determine the opinion of modern natural- ifts, who require accurate and repeated experiments.

Lime is made ufe of in many of the arts; more efpe- cially in building. In medicine, lime-water is fuccefs- fully prefcribed in ulcerous cafes, &c. It has been thought a powerful lithontriptic. But long experience has fhown, that it does not always operate the cures expected from it ; and that where the ufe of it is too long continued, it produces on the animal fluids an al- teration approaching to fcurvy or fepticity *.

C H A P.

* Mr Kirwan fays, that in hot water, lime is ¼ more foluble than in water of the common temperature of 60° Fahrenheit. From Lavoifier we learn, that 1000 parts of lime are capable of abforbing and retaining, at the heat of 600° Fahrenheit, 228 parts of water. Bergman makes the fpecific gravity of lime to be 2,720.—H.

CHAP. III.

Genus II. *Alkali Salts.*

ALKALIS come to be treated of before acids, because they appear to be more simple and less decompofable, and because they referable in some properties the falino-terrene fubftances. They have an urinous acrid cauftic tafte : they turn fyrup of violets green, excite heat in uniting with water, abforb both the moifture and the carbonic acid of the atmofphere, and diffolve earths by the force of their tendency to combination *. Three fpecies of alkalis are known ; potafh, or *vegetable fixed alkali ;* foda, or *mineral fixed alkali;* and ammoniac, or *volatile alkali.*

Species I. *Potafh.*

THIS fpecies, which we denominate *potafh,* has been called *vegetable, fixed alkali ;* becaufe, though often met with in minerals, it is found in greateft abundance in vegetables. It has likewife been named *alkali of tartar,* becaufe a confiderable quantity of it may be obtained from this faline fubftance ; which will afterwards come under our examiuation. Dr Black was the firft who difcovered potafh in a ftate of purity. Formerly this falt was called *cauftic fixed alkali,* to diftinguifh it from common fixed alkali.

This

* To thefe qualities may be added, the property of rendering oil mifcible with water.—H.

This ſalt, in a ſtate of conſiderable purity, is white and of a dry ſolid form : its ſapidity is ſo ſtrong, that it diſſolves the texture of the ſkin. It communicates inſtantaneouſly to the ſyrup of violets a deep green colour, much more obſervable than that which lime cauſes the ſame ſyrup to aſſume. It alters, and almoſt entirely deſtroys this colour, changing it to a brown yellow.

We know not in what manner light affects this ſalt.

Potaſh, when expoſed to the action of fire in cloſe veſſels, is inſtantly ſoftened, and by the time when it begins to appear red, becomes entirely liquid. If it be then poured on a ſmooth hard ſurface, it cools into a white, opaque, brittle maſs. It is not decompoſable by heat. A moſt intenſe heat, ſuch as that of the furnace of a glaſs-houſe, is requiſite to volatilize it. In all theſe operations it diſſolves part of the clay veſſels in which it is contained.

When expoſed to the open atmoſphere, it attracts moiſture ſtrongly, diſſolves into a liquid, and gradually paſſes into the ſtate of a neutral ſalt, by abſorbing the acid diffuſed through the atmoſphere. By this means, it acquires on ſuch occaſions an increaſe of weight, and becomes capable of efferveſcing with acids; which never takes place when it is in that ſtate of purity in which we have ſuppoſed it. To preſerve it pure, therefore, it muſt be kept in cloſe veſſels entirely full of it.

Potaſh diſſolves very readily in water ; it then excites a conſiderable degree of heat, and exhales a fetid lixivious odour. The ſolution is colourleſs ; and when very pure, affords no precipitate. To ſeparate it from

the ſolvent, the ſolution muſt be evaporated to dry-
neſs in cloſe veſſels. If this operation be performed in
open veſſels, the acid of the atmoſphere is attracted,
and renders the pot-aſh efferveſcent. And this abſorp-
tion takes place ſo readily ; that if a ſolution of this
ſalt be expoſed to the open air for ever ſo ſhort a ſpace
of time, it ſuffers an alteration, and is in fact neutra-
lized. In a flaſk which it does not entirely fill, and
which is frequently opened, it is liable to the.ſame alte-
ration. The action of oxigene and azote on this alkali
is not known.

Potaſh combines with ſilice in the dry way, and
cauſes it to melt together with itſelf : the two compoſe
a tranſparent body, known by the name of *glaſs.*
This body is liable to varieties from the various pro-
portions in which the ſiliceous ſand and the fixed alka-
li are united in it. Two parts of the ſalt with one of
earth afford a ſoft brittle glaſs, which attracts moiſture,
and becomes at length opaque and fluid. This glaſs is
ſoluble in water, on account of its containing ſo much
more than an equal proportion of alkali. The ſolution
is called *liquor of flints.* It at length depoſites part of
the earth which it contains, in white ſemi-tranſparent
flakes, apparently mucilaginous, and ſo light that they
ſubſide but very ſlowly. Acids ſeize the alkali, and
precipitate the earth, which is called *earth of flints.*
But to make this proceſs ſucceed, care muſt be taken
that the liquor of flints be not too much diluted by the
water. In that caſe, the particles of the earth being
too much divided, remain ſuſpended in the liquor, and
evaporation is requiſite to produce the precipitate
Several chemiſts are of opinion, that earth of flints

n.

not the ſame with ſiliceous earth ; on which they think the alkali has produced an entire alteration. They think it to be more like aluminous earth, and believe that by combination with acids, it affords the ſame ſalts which are obtained by combining acids with aluminous earth. Such was the opinion of Pott and M. Baumé. But Scheele has ſhown, that that portion of the earth precipitated from liquor of flints, which is ſoluble in acids, is part of the aluminous earth of the veſ-ſel in which the operation is performed, diſſolved by the mixture of alkali and ſiliceous earth.

The art of making glaſs is entirely chemical, as glaſs is nothing but a combination of fixed alkali with ſili-ceous earth. The purity, the proportion, and the complete fuſion of theſe two ſubſtances by a fire ſufficiently intenſe, and kept up for a proper length of time, are the three conditions requiſite for the preparation of glaſs, of a proper tranſparency, of ſufficient hardneſs, and liable to no alteration from the attacks of air. We ſhall afterwards learn what other ſubſtances are mixed with theſe two in this compoſition, in order to render the glaſs more weighty and tranſparent, and to communicate to it ſeveral other properties which render it fitter for the purpoſes to which it is applied.

Potaſh acts not with the ſame force on aluminous as on ſiliceous earth : but the phenomena which it exhibits, when applied to alumine, are not yet well known.

This ſalt appears to be ſuſceptible of combination with barytes, magneſia, and lime. But its combinations with theſe ſubſtances have ̄   ᵉᶜᵘ-

rately examined as to admit of our giving a particular
account of them here.

Although potafh has never yet been decompofed;
yet a number of facts with which the reader fhall be
hereafter made acquainted, concur to fhow that it is
not a fimple fubftance. Stahl, who confidered fimple
falts as a combination of earth and water, thought that
fixed alkali differed from the acids only by containing
a greater proportion of earth : and in this manner he
accounted for its drynefs, &c. Potafh, in all probabi-
lity is a combination of fome one of the three preceding
earths with azote. Some analogies lead me to think
that it contains lime. But this conjecture is not yet fup-
ported by a fufficient number of facts.

Potafh is ufed in furgery to corrode the fkin, and pro-
duce inflammation and fuppuration in certain cafes *.

Species II. *Soda.*

THIS faline fubftance, which exhibits the fame gene-
ral characteriftics with the foregoing, has received the
name of *mineral fixed alkali* : It is found in abundance,
combined with a peculiar acid falt in fea-water, and in
fome fpring-waters : fometimes too it is met with in ve-
getables, but much feldomer than potafh. This
falt has been called *marine alkali*, from its making a
part of marine falt ; and *alkali*, or *falt of foda*, becaufe
it is ofteneft obtained from this fubftance. We prefer
the fimple name of *foda*.

The

* Potafh is extracted by *lixiviation* and fubfequent *concentration*, from
the afhes of wood, ferns, and other vegetables. That which we ufu-
ally meet with in commerce, is manufactured chiefly in North Ameri-
ca, or in the northern countries of the continent of Europe. However,
this potafh is not pure, but always more or lefs contaminated and neu-
tralized.—H.

The taſte of ſoda is equally ſtrong and cauſtic with that of potaſh. It turns the ſyrup of violets green, and produces the ſame alteration as potaſh on this colour: it appears naturally in a dry and ſolid form. It melts in fire as it begins to become red-hot : a violent heat volatilizes it : it acts on almoſt all the veſſels in which it can be expoſed to heat.

When expoſed to atmoſpheric air, it attracts its moiſ-ture, and the peculiar acid which it contains : ſo as to become gradually a neutral ſalt. The manner in which it is affected by oxigene and vital air is not yet known.

It diſſolves in water with heat, and the diſengagement of a fetid lixivious odour. It cannot be obtained pure after this ſolution but by evaporation in cloſe veſſels. The lixiviate, when expoſed to the air, readily abſorbs its acid, and becomes neutral. Therefore, to preſerve it pure, it muſt be kept in cloſe veſſels.

Soda readily combines with ſiliceous earth in the dry way, ſo as to compoſe glaſs. Glaſs-makers have even obſerved it to be more fuſible, and to adhere more rea-dily and firmly with this earth than potaſh ; to which they on this account prefer it. And therefore what was ſaid above concerning the uſe of potaſh in glaſs-making, may be applied to ſoda. Laſtly, this alkali, as well as potaſh, combines with acids and many other bo-dies, as we ſhall afterwards underſtand.

After this account of the properties of ſoda, we muſt obſerve, that there is no very remarkable difference be-tween potaſh and ſoda when both are in a ſtate of puri-ty. It is only in their combinations that the difference of their natures can be diſtinguiſhed. When combin-

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ed with the ſame acid, they afford neutral ſalts totally
different from each other ; and this is the more ſurpriſ-
ing becauſe it is impoſſible to diſtinguiſh the one from
the other when they are in a pure cauſtic ſtate, as
we have here examined them.   Bergman adds another
diſtinctive property of theſe ſalts which is well worth
knowing ; they have not the ſame affinity with acids.
Potaſh has a ſtronger affinity with theſe ſaline ſubſtances
than ſoda : and is capable to decompoſe neutral ſalts,
confiſting of combinations of the latter.   We ſhall take
farther notice of this when we come to examine ſecon-
dary or neutral ſalts.

The compoſition or intimate nature of ſoda is equally
unknown as that of potaſh.   The ſame analyſis leads
me to think that ſoda, as well as potaſh, is a combina-
tion of an earth with azote ; and that it is the difference
of the earthy baſe which forms the characteriſtic diffe-
rence between the two ſalts.   Magneſia is poſſibly the
baſe of ſoda, as I have for ſome years hinted in my
lectures, and M. Lorgna has ſince attempted to
prove.   But the facts on which this opinion is found-
ed, are not ſufficiently exact and numerous to juſ-
tify our conſidering it as a certain truth.   As to its
uſes, it is employed in making glaſs, in preparing ſoap,
&c. *.

Species

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* The aſhes of ſea-plants, which are annually burnt to fuſion a-
round the coaſts of Scotland and its contiguous iſlets ; and are ſold,
under the name of *kelp*, are valuable only for the ſoda which they con-
tain.   Soda is likewiſe produced, ſeparately, by nature, in two lakes
in Egypt.   It is there known by the name of *natron*—H.

Species III. *Ammoniac.*

WHAT we call *ammoniac* is a ſalt commonly known by the name of *volatile alkali.* It is diſtinguiſhed from the two foregoing ſalts by a keen ſuffocating ſmell and a remarkable volatility. This ſalt, like the fixed alkalis, was not known in a ſtate of purity before the ingenious experiments of Black and Prieſtley. A certain imperfect neutral ſalt was miſtaken for it, which is ſolid and cryſtalliſed, and poſſeſſes indeed ſome of the properties of volatile alkali, but is really a compound of two ſaline ſubſtances. The property of efferveſcing with acids, which has been aſcribed to volatile alkali, belongs only to that neutral ſalt, which will be afterwards deſcribed.

That which is known in the laboratory under the name of *cauſtic,* or *fluor volatile alkali,* and in pharmacy by the name of *volatile ſpirit of ſal ammoniac,* is not pure ammoniac; it is only a ſolution of ammoniac in water. Dr Prieſtley has ſhown, that by the operation of a gentle heat, a permanent gas may be extracted from it; and that the water, when deprived of this gas, gradually loſes its alkaline properties. This aëriform fluid is ammoniac, and is known by the name of *ammoniac gas.* This is the body whoſe properties we muſt examine, if we wiſh to know thoſe of genuine *volatile alkali;* as Macquer has very properly obſerved.

To obtain this elaſtic fluid, put into a ſmall retort or a glaſs matraſs a certain quantity of liquid ammoniac. Adapt to the retort, or the matraſs, a curved tube or ſyphon; the extremity of which is to be immerſed

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into a pneumato-chemical machine filled with mer-
cury; ſo that.it may be received under an inverted
glaſs filled with the ſame metallic fluid. Heat the bot-
tom of the retort or matras with burning charcoal or
the flame of ſpirit of wine. Suffer the firſt part of the
elaſtic fluid, which is moſtly common air from the veſ-
ſel and the tube, to eſcape; and as ſoon as the ebulli-
tion becomes ſtrong, collect the gas in the inverted
glaſs. The diſtillation muſt not be carried ſo far as to
evaporate the water; or at leaſt the tube which is
uſed ſhould in the middle ſwell into a bowl that may
be kept cool, ſo as to condenſe the vapour: the am-
moniac gas will then be obtained very dry and pure.

The gas thus obtained reſembles air, and has the
ſame tranſparency and elaſticity. It is rather lighter,
however; its ſmell is more penetrating; and its taſte is
acrid and cauſtic. It inſtantly converts the blue co-
lour of violets, mallows, and radiſhes, into a deep
green, but does not alter it, as the pure fixed alkalis do.
It kills animals, and corrodes the ſkin, if expoſed for
any time to its contact.

Though it does not ſerve to maintain combuſtion, but
extinguiſhes bodies in inflammation, yet it increaſes be-
fore extinguiſhing the flame of a wax-candle: it ren-
ders its bulk ſomewhat more conſiderable, and cauſes
it to aſſume a pale yellow colour round the edge.
This fact proves that ammoniac gas is partly inflam-
mable.

Porous bodies, ſuch as charcoal, ſponge, &c. ab-
ſorb it.

Dr Prieſtley has diſcovered, that the electric ſpark,
in paſſing through ammoniac gas, renders its bulk
three

three times greater than before, and diſengages from it a portion of hydrogenous gas. The cauſe of this phenomenon is hitherto unknown; only it appears that the ammoniac is decompoſed in this experiment, and that the two matters, of which, as we ſhall preſently ſhow, it is compoſed, are ſeparated, and paſs into the ſtate of elaſtic fluids.

Ammoniac gas is one of thoſe elaſtic fluids which heat dilates the moſt. Atmoſpheric air does not combine with this gas; it only dilates and divides it. The action of vital air on this fluid has not yet been examined.

Water readily abſorbs ammoniac gas: if in the ſtate of ice, it immediately melts with cold; but on the contrary, this gas communicates heat to fluid water. Water ſaturated with this gas, or liquid ammoniac, is the ſubſtance known by the name of *fluor* and *cauſtic volatile alkali.* We ſhall hereafter ſee that the pureſt and moſt concentrated volatile alkali is prepared by receiving the gas into diſtilled water till the liquid be ſaturated with it.

Ammoniac gas has no diſcernible action on earths or ſalino-terrene ſubſtances; but it acts vigorouſly on acids and a number of neutral ſalts, as we ſhall hereafter ſee. Liquid ammoniac has the ſame properties as the gas; only, it poſſeſſes them in a leſs eminent degree: For the gaſeous aggregation being, according to one of the laws of affinity, much weaker than that of liquids; of conſequence, ammoniac gas muſt have a greater tendency to combination than liquid ammoniac.

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This

344   *Saline Subftances.*

This falt has been confidered as a combination of fixed alkali with a combuftible fubftance. What gave rife to this conjecture was, that, in many inftances, fixed alkalis, when heated with inflammable matters, produce ammoniac. But it was not known whether, on fuch occafions, fixed alkali entered entire into the compofition of ammoniac, or only fupplied a peculiar principle, which, by combining with part of the combuftible matter, formed this falt. The nature of ammoniac is at prefent fomewhat better known. The fine experiment of Dr Prieftley, in which he changed alkaline into inflammable gas, by means of the electric fpark, made feveral chemifts fufpect this laft fubftance to be one of the principles of ammoniac. M. Berthollet having engaged in a particular feries of experiments with a view to determine this, has at length fhown ammoniac to be a compound of the hydrogenous and the azotic principles, with a certain quantity of the caloric. He has drawn this induction from obferving the action of oxigenated muriatic acid on ammoniac, the decompofition of ammoniacal nitrate in clofe veffels, and the reduction of metallic oxides by means of ammoniac. Each of thefe facts will be particularly examined in our hiftory of the compound fubftances into which ammoniac enters. Here we fhall content ourfelves with obferving, that by heating combinations of the oxides of copper and gold with ammoniac, water and gas azote are obtained, and the metals are reduced. In fuch operations the ammoniac is decompofed, a hydrogene combining with the oxigene of oxides, forms the water; the meta'

the azote, the other principle of the ammoniac, beco-
ming free, combines with the caloric, and the two are
difengaged in gas azote. Berthollet concludes ammo-
niac to confiſt of ſix parts of azote and one of hydro-
gene, with a certain quantity of caloric *.

Ammoniac diluted in water is adminiſtered in a great
many difeafes. It is aperient, and powerfully incifive.
It acts ftrongly on the ſkin ; it is prefcribed as a reme-
dy for the bite of vipers, and for cutaneous and vene-
real complaints, &c.

As it is acrid and cauſtic, it is to be very cautiouſly
ufed. Externally applied, it is very ferviceable in
difcuffing tumours, efpecially fuch as are formed by
coagulated milk, lymph, &c. I have prefcribed it
fuccefsfully in thefe cafes : it is a ready cure for burn-
ings; and is often fuccefsfully applied for chilblains, &c.
It has been long ufed, and under a variety of names,
as a moſt active ftimulant in cafes of fyncope, apoplexy,
&c. But it ſhould be ufed in very moderate quantities
in thefe latter cafes : it is dangerous to adminiſter it in-
ternally, unlefs diluted in a large quantity of water.
Alarming excoriations have fometimes been produced
on the duct of the œfophagus and the membranes of
the ftomach, in cafes where it has been raſhly admini-
ſtered.

C H A P.

* the azote is in proportion to the hydro-

CHAP. IV.

Genus III. *Acids.*

ACIDS are known by their four tafte when dilu-
ted in water; they convert blue vegetable co-
lours to red; many of them appear under a gafeous
form; they combine rapidly with alkalis; they act
much more powerfully than alkalis on combuftible bo-
dies, often reducing them to a ftate of calcination. As
inflammable matters, efpecially metals, are found to
contain a confiderable quantity of oxigene after they
have been expofed to the action of acids; while thefe
again are found to have paffed at the fame time into
a combuftible ftate : from thefe facts it may be infer-
red that acids are by no means the fimple bodies they
were thought to be, but are in general compounds of
an inflammable matter, combined with oxigene.

We are acquainted with ten different fpecies of acids
in the mineral kingdom. We find alfo, in the fame
divifion of nature, the phofphoric acid, united with iron,
lead, and lime.

The carbonic acid.
The muriatic acid.
The fluoric acid.
The nitric acid.
The fulphuric acid.
The boracic acid.

The molybdic acid.

The tunftic acid.

The arfenic acid.

The fuccinic acid.

We fhall here treat of the firft fix, which are the moft plenteous and beft known ; the other four will be examined elfewhere.

Species I. *The Carbonic Acid.*

WE give the name of the *carbonic acid* to an acid which occurs in great abundance through the whole of nature, and which appearing often in the ftate of an aëriform fluid, was at firft called by the Englifh *fixed air ;* afterwards by Meffrs Bewly and de Morveau *the mephitic acid ;* by Macquer *mephitic gas ;* by Bergman *the aërial acid ;* and by Bucquet *the cretaceous acid.* The propriety of the denomination which we have adopted will afterwards appear.

This fubftance was not always thought to be an acid. Its leading properties were obferved by Paracelfus, Van Helmont, Hales, &c. But we are indebted to Meffrs Black, Prieftly, Bewly, Bergman, and Chaulnes for our knowledge of its acidity.

The gafeous carbonic acid poffeffes all the apparent charaćteriftic properties of air. Like air, it is invifible and elaftic ; and when inclofed in a glafs veffel, or floating in the atmofphere, it cannot be certainly diftinguifhed from that· fluid. It is one of the prin·inlae of atmofpheric air, but the moft fcanty in the compofition.

compofition *. It is found perfectly pure in fubter-
raneous cavities, which it entirely fills, as in the
grotto del cane. It is combined with a greater number
of natural bodies, fuch as mineral waters and many
neutral falts; fpirituous fermentation produces great
quantities of it. It is alfo formed by refpiration and the
combuftion of coals: Laftly, it is conftantly exhaled
from all parts, and more efpecially from the leaves, of
plants in the fhade.

Though this acid, in the ftate of an elaftic fluid, has
all the appearance of air, yet it poffeffes different phy-
fical properties; its fpecific gravity, for inftance, is
double that of air. Like all other fluids, it may be
poured from one veffel into another; it flows from the
cock of a wine-cafk, after the wine is drawn off; its
tafte is pungent and fubacid; it is inftantaneoufly fatal
to animals, becaufe it affords no fupply for refpiration;
it extinguifhes flaming tapers, and all bodies in com-
buftion. It communicates to the tincture of turnfole a
bright red colour. That colour vanifhes gradually in
the air as the acid evaporates. It produces no altera-
tion on the colour of violets, as it acts but very feebly
on very deep and fixed colours.

This acid has but a very faint tendency to combina-
tion; the weakeft indeed of all the bodies of the kind.

It

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* M. Lavoifier's ingenious experiments have led him to confider
atmofpheric air as a compound of vital air, carbonic acid, and azo-
tic gas, moft commonly in the following proportions.

Vital air,	-	-	• 27
Carbonic acid,	•	-	- 01
Gas Azote,	-	•	.. 72

Total 100

It fuffers no difcernible alteration from the contact of light.

Heat dilates it, but produces no change in the mix-ture.

It mixes with vital air, without fuffering any altera-tion; and the mixture will maintain refpiration as long as the carbonic acid does not exceed a third part of it. On this account, it admits of being ufed as a remedy in difeafes of the lungs.

It combines with water but very flowly. By fhaking thefe two fluids together, fo as to bring them as much as poffible into contact with one another, they are made to unite and form an acidulous liquor. Bergman gives to this folution the name of *aërated water.* But this name belongs more properly to water containing atmo-fpheric air, which it may ferve to diftinguifh from boiled water that has been deprived of its air by heat. The colder water is, the more of the carbonic acid does it diffolve. But there is a point of faturation; even the coldeft water cannot abforb a quantity greater than is equal to its own bulk.

Water faturated with carbonic acid is fomewhat hea-vier than diftilled water. Agitation makes it fparkle; it has a pungent, acidulous tafte, and reddens the tinc-ture of turnfol. It is decompofable by heat; which foon brings it to a ftate of ebullition, and difengages the elaftic fluid. The contact of air produces the fame effect more rapidly in proportion as its temperature is higher. Therefore, in order to preferve this acidulous liquor, it muft be inclofed in veffels properly ftopped, and ftanding in a cool place, or under ftrong compreffion.

This acid folution abounds throughout nature. Of it

acidulous and gazeous waters, fuch as thofe of Pyr-
mont, Seltz, &c. confift.

As this acidulated water is a remedy in all putrid dif-
orders, either by drinking or bathing, naturalifts have
invented an apparatus for impregnating with eafe, and
with all poffible quicknefs, any quantity of water with
as much of the carbonic acid as it can maintain in folu-
tion. Dr Prieftley, in the year 1772, gave the firft ac-
count of a procefs for acidulating water that was offer-
ed to the public. Dr Nooth has invented a machine
for this purpofe, which has been improved by Mr Par-
ker, and ftill farther improved by Mr Magellan. It is
at prefent to be found in all philofophical laboratories.
There is an excellent defcription, and an engraving of
it, in Dr Prieftley's Experiments on the different kinds
of Air, p. 112 to p. 118; and in Mr Magellan's letter
in the fame work, vol. v. page 83.

The carbonic acid does not act upon filiceous earth.
It is well known that acidulated water alone never cry-
ftallifes filiceous earth; as was fome years fince repre-
fented to the public.

The carbonic acid unites with alumine, barytes, and
magnefia. With thefe fubftances it forms various neu-
tral falts, which we fhall afterwards have occafion to
examine.

The combination of this acid with lime diffolved in
water, gives rife to an invariable phenomenon, which al-
ways indicates the prefence of the acid. As foon as it
touches the liquid, it produces white clouds, which foon
thicken and form a plenteous precipitate. Thefe clouds
are owing to the chalk, or carbonate of lime, formed by
the combination of lime with the carbonic acid. This
new

new falt, not being foluble in pure water, is feparated, and fubfides to.the bottom of the fluid. Lime-water is therefore a teft, by which we may diftinguifh the nature and the quantity of the acid under examination. If, after this precipitation, more of the acid be added, the precipitate will again be diffolved by the additional quantity of the carbonic acid, and will then difappear. Here is a fecond charaĉteriftic by which this acid may be known. The chalk thus diffolved by the addition of a fecond quantity of the carbonic acid, is again precipitated when the liquor is heated or expofed to the air, or laftly, by all the proceffes which carry off the fuperfluous quantity of the carbonic acid. Thus, I have remarked, that the cauftic fixed alkalis and pure ammoniac, when poured into a folution of chalk with the carbonic acid, caufe a precipitation by abforbing part of the acid.

Acidulated water, if poured into lime-water, produces upon it precifely the fame effeĉts.

The carbonic acid combines rapidly with the three alkalis. If a fmall quantity of pure cauftic fixed alkali, in a liquid ftate, be put into a veffel filled with this acid, obtained from chalk or from beer in a ftate of fermentation ; and the mouth of the veffel be immediately clofed with a wet bladder : the bladder will be feen to contraĉt gradually, on account of the vacuum produced in the veffel by the alkali abforbing the carbonic acid. The combination of thefe two acids is attended with heat ; and the fides of the veffel are foon covered with cryftals which become gradually larger. This falt is called *carbonate of potafh*, or *carbonate of foda*, according as the one or the other of thefe fixed

3

alkalis is employed. Thefe two genuine neutral falts were formerly called *falt of tartar*, and *falt of foda.* We fhall examine their properties in the following chapter.

Ammoniac gas, and the aëriform carbonic acid brought into contact in a clofe veffel, alfo produce inftantaneoufly a vacuum, heat, and a thick white cloud which forms into regular cryftals, or fimply into a cruft, on the fides of the veffels. This is an imperfect neutral falt, to which we may give the name of *ammoniacal carbonate,* and which was formerly called *concrete volatile alkali, Englifh falt,* &c.

The carbonic acid does not adhere to all of thefe bafes with the fame force. According to Bergman, barytes is the fubftance with which it has the greateft affinity; next in order come lime, potafh, foda, magnefia, and ammoniac. We will have occafion in the hiftory of neutral falts to take notice of the facts on which Bergman has eftablifhed this order of affinities.

The nature and compofition of this gafeous acid, have for fome years much engaged the induftry of chemifts. Prieftley, Cavendifh, Bergman, and Scheele, feem to agree in thinking it a compound of vital air with phlogifton. But as the exiftence of that principle has been with reafon queftioned by a number of celebrated French chemifts, who have urged many difficulties and objections againft it, to which no fatisfactory anfwer can be given, we cannot therefore admit of this theory. I once thought that the carbonic acid might be a compound of inflammable gas with pure air ; but the difcovery of the nature and the decompofition of water renders that conjecture improbable; and M. Lavoifier

has

has fupplied it in its room a fact fupported by demon-
ftrative evidence.

This chemift, to whom the fcience is indebted for fo
many ingenious and nice experiments, burnt a certain
quantity of charcoal, deprived of all its hydrogenous
gas by a previous calcination in clofe veffels,—in in-
verted glaffes, filled with mercury above a portion of
air: for he had obferved, that if the operation were
performed without the precaution of calcining the coal,
drops of water would be 'obtained, and would neceffa-
rily render the calculation inaccurate. This operation
was performed by means of a quarter of a grain of aga-
ric tinder, placed on a bit of coal, and covered with a
very fmall quantity of phofphorus : a piece of iron wire
bent, and made red hot, paffed through the mercury, fo
as to kindle the phofphorus; the phofphorus communi-
cated the inflammation to the agaric tinder, which a-
gain communicated it to the coal; the inflammation
was very rapid, and accompanied with much light.
The whole apparatus being cold, M. Lavoifier introdu-
ced into the glafs a portion of liquid fixed cauftic alkali;
which abforbing the acid formed during the combuf-
tion, left part of the vital air as pure as at the beginning
of the experiment. This chemift is of opinion, that in
this experiment the oxigene, which by combining with
caloric formed the vital air,—produced a portion of the
carbonic acid by combining with the matter of the coal,
while the other principle of the fame vital air was dif-
engaged under the form of heat and light. A portion
of afhes remained; and the quantity of the acid formed
was equal in weight to the vital air confumed, and the
weight which the coal had loft. From a number of ex-

periments of this kind, M. Lavoifier concluded, that a quintal of the carbonic acid, the name of which the reader may now perceive to be founded on its nature, confifts of about 28 parts of pure carbonaceous matter, and 72 of oxigene.

He thinks, that in the refpiration of animals, a real carbonaceous matter is actually difengaged from the blood, which by combining with the oxigene of the atmofphere, forms the carbonic acid, which is conftantly produced by refpiration; and that in the fame manner the carbonic acid, difengaged in fpirituous fermentation, is produced by the combination of the carbonaceous matter of fugar with the oxigenous part of water.

Several philofophers have obferved, that this acid, in a ftate of fluid elafticity, poffeffes the property of preferving animal fubftances, retarding their putrefaction, and even reftoring them to a found and frefh ftate after putrefaction has begun to take place. From this fact Macbride has inferred, that the acid unites with the body, thus reftoring to it what it loft by putrefaction. This latter phenomenon, in his opinion is occafioned by the natural decompofition of organic matter, and the diffipation of the carbonic acid they contain, which he calls *fixed air*; and therefore he afferts the ufe of this acid to be indifpenfably neceffary, in order to afford to animals a fupply of what they are fo conftantly lofing, and to reftore the fluids when altered by motion and heat. He acknowledges the exiftence of this acid in frefh vegetables, more efpecially in fuch as are fufceptible of fermentation; as a decoction of barley which has been fuffered to germinate, the infufion of raifins, &c. all of which, he thinks, may be with equal propriety

propriety prefcribed in difeafes occafioned by the feptic motion of the humours; fuch as the fcurvy.

Water impregnated with the carbonic acid has been alfo propofed as a remedy in putrid bilious fevers; and has been ufed with fuccefs in a number of inftances: The Englifh are faid to ufe the carbonic acid, mixed in a low and unequal proportion with common air, in difeafes of the lungs.

It has been ftrongly recommended as a lithontriptic, or folvent of the ftone in the bladder. But there is no well authenticated inftance of its being fuccefsfully ufed in France again this dreadful diftemper. Befides, this is contradictory to what Scheele and Bergman have dif-covered concerning the ftone in the bladder; of which we fhall elfewhere fpeak.

The newfpapers have given accounts of a number of cancerous cafes cured in England by the ufe of carbonic acid. But we can affert, that we have often feen it ufed in fuch cafes, and have even tried it ourfelves, ftill without effect. After the firft applications, the cance-rous ulcer feems to affume a more favourable afpect; the fanies which ufually flows from it becomes white, con-fiftent, and fomewhat pure; the flefh affumes a frefh lively colour; but thefe flattering appearances are falla-cious, and do not continue; the ulcer foon returns to its former ftate, and its progrefs goes on as before.

The period of the firft difcovery of this acid by Dr Black is to be confidered as one of the moft illuftrious æras of chemical fcience. To point out the influence of this difcovery upon the fcience, we fhall here offer the following remarks. 1. It has made us acquainted with a peculiar acid. 2. It has explained the caufe of

the effervefcence of the common alkalis, chalk, calca-
reous fpar, and magnefia, when mixed with acids
ftronger than themfelves. 3. It has enabled us to di-
ftinguifh all alkaline matters as exifting in two ftates,
pure and cauftic, or *foft*, *with the property of caufing ef-
fervefcence.* 4. It has thrown new light on the hiftory of
the elective attractions of ammoniac and chalk for the
acids. 5. It has furnifhed us with one of the firft in-
ftances of an acid preferring lime to the fixed alkalis.
6. The hiftory of places containing mephitic air, caverns
which are inftantly fatal to the life of animals, is be-
come fince this difcovery more fimple and intelligible.
7. To the former analyfes of waters, we have been en-
abled to add by this difcovery an accurate knowledge
of gafeous, fpirituous, and acidulous waters; fo that we
can now produce by rule the moft perfect imitations of
them. 8. It has likewife made us much better ac-
quainted with the folutions of iron contained in various
waters; and has taught us how to make up martial
waters exactly refembling thofe of nature. 9. It has
made us acquainted with a new clafs of neutral falts
alkaline and metallic, which have the carbonic acid
for one of their principles, and to which we fhall there-
fore give the name of *carbonates* in this work. 10. It has
opened a new tract for the refearches of naturalifts and
chemifts, and has roufed that ardour for fuch purfuits, to
which we are indebted for all the fine difcoveries which
have been made fince that period. The name of Black
will therefore be famous in the annals of chemiftry as
long as the fcience fhall be cultivated.

As to the production of this acid by the electric
fpark paffing through vital air, we muft obferve, if

in the experiments of M. Landriani, the iron ufed as the conductor of the electric fluid, is evidently the caufe of the phenomenon by means of the plumbago, or carbure of iron, which it contains. The trivial quantity of the acid obtained, is an unequivocal proof of this.

There are, no doubt, many cafes in which the carbonic acid is decompofed and refolved into its principles, as well as other acids : Thus, for inftance, water faturated with this acid is much fitter than diftilled or common water for the production of vital air on leaves expofed to the rays of the fun : the vegetable fubftance feems to abforb the carbonaceous matter, while the light, acting like heat, contributes by feparating the oxigene, to the production of vital air. It is likewife very remarkable, that certain oxides of iron, diftilled in a pneumato-chemical machine, afford only carbonic acid as they pafs to the ftate of æthiops or black oxide of iron. This depends either on the carbonaceous matter, or the plumbago contained in feveral kinds of iron. The carbonaceous matter, by abforbing part of the oxigene of the iron, forms the acid which is difengaged. Thefe newly difcovered facts will be explained more at length in fome of the following chapters of this work *.

Species II. *The Muriatic Acid.*

In the laboratories, the name of *marine acid*, or *fpirit of falt*, or *liquid muriatic acid*, is given to a fluid of the confiftency of water, of a tafte ftrong enough to

Z 3   corrode

* According to Kirwan, the proportion of carbonic acid to that
. of common air, is, as *   her makes it 69,50 to
. 48,81. The propor   bonis.
acid, is as 12;c288

corrode our organs when it is concentrated; but which, when diluted in water, affects the tongue only with a fournefs and ftipticity. This fluid, when perfectly pure, is abfolutely colourlefs. When it is red, or citror-coloured, like the marine falt of the fhops, it owes its colour to fome combuftible fubftances, frequently to iron, which alters it. This acid is obtained from marine falt or muriate of foda, as we fhall fee in the hiftory of that falt. If ftrong and concentrated, it exhales when expofed to the air a white vapour or fmoke. It has a lively penetrating fmell, which when faint or much diluted, refembles the fmell of citrons, or the apple called the *golden rennet.* It is then called the *fuming muriatic acid.* Its vapour rifes moft copioufly when the air is moift. If, on opening a flafk full of this acid, you put your hand to its orifice, you feel a fenfible heat; which is occafioned by the combination of the acid in the ftate of vapour with the water of the atmofphere.

The muriatic acid communicates a deep red to the fyrup of violets, and all blue vegetable colours, but does not abfolutely deftroy them. This liquor, however concentrated and fuming, is not muriatic acid in a pure and feparate ftate; but muriatic acid combined with a confiderable quantity of water. Dr Prieftley has eftablifhed this truth beyond a doubt, by fhowing that this acid may be reduced to a gas, and rendered permanent in that ftate, over a portion of mercury, by the temperature and preffure of the atmofphere: we muft therefore examine the properties of this gas, if we wifh to acquire a knowledge of thofe of the muriatic acid, unmixed and in a ftate of purity.

The

The muriatic acid gas is obtained by heating the li-
quid fuming acid in a retort, the extremity of which
enters a bell-glafs full of mercury. The gas being much
more volatile than the water, paffes through the retort
into the glafs ; it difplays all the apparent properties of
common air, but is more ponderous. It has a keen
penetrating odour ; and is fo cauftic that it inflames
the fkin, and often occafions violent itchings. It fuf-
focates animals, and extinguifhes the flame of a taper,
after magnifying it and caufing it to affume a green or
bluifh flame round its edges. Spongy bodies abforb this
acid.

Light does not appear to alter it in any fenfible de-
gree. Heat rarefies it, and increafes its elafticity a-
mazingly. Atmofpheric air, mixed under bell-glaffes
with muriatic gas, caufes it to affume a fumy or va-
porous form, and is gently heated ; from which it ap-
pears that a combination actually takes place. When
the air is humid, thefe vapours are more difcernible :
M. d'Arcet has obferved that they are not perceptible
on the tops of high hills, where the air is very dry. The
white vapours exhaled by the muriatic acid gas are
therefore owing to the water contained in the atmof-
fphere. Neither the liquid acid nor the gas abforbs vi-
tal air in a ftate of elafticity, in any fenfible degree ;
yet fome properties, which we fhall mention by and by,
enable them to combine with the oxigenous principle.
It is afferted that the liquid muriatic acid may be cau-
fed to abforb a portion of vital air, by fhaking them
violently together.

The muriatic acid gas combines rapidly with water.
Ice, on coming into contact with it, inftantly melts, to

abforb

abforb it. Water uniting with this gas acquires a con-
fiderable heat. When faturated with it, it cools and
becomes the fame with the liquid acid from which the
gas was obtained ; it exhales white vapours, is colour-
lefs, reddens fyrup of violets, &c. We fhall afterwards
fee, that the moft concentrated and pure liquid muria-
tic acid is obtained by faturating pure water with the e-
laftic fluid.

The muriatic acid gas has no power of action on fili-
ceous earth ; it combines with aluminous earth, and by
this combination forms aluminous muriate.

It unites with the falino-terrene fubftances, forming
in combination with them barytic, magnefian, and cal-
careous muriates.

Its combination with potafh is *the febrifuge falt of
Sylvius*, or muriate of potafh : with mineral alkali or
foda, it gives marine falt, common falt, or muriate of
foda.

The muriatic acid gas when brought into contact with
ammoniac gas, acquires a confiderable heat. The two
elaftic fluids penetrate each other, a white cloud in-
ftantly rifes, the mercury is elevated in the glaffes,
and the fides of the glaffes are foon covered over with
ramified cryftals, which are fal ammoniac, or ammoni-
acal muriate. If the two gafes be very pure, they
difappear entirely when the concretions are formed,
and the heat difengaged. This experiment among o-
thers proves, 1. That bodies which pafs from a liquid
to a folid ftate, abforb in their tranfition a certain quan-
tity of the caloric principle, or the matter of heat; for
the caufe which converts the muriatic acid into a gas,

is

is its receiving an additional quantity of heat. 2. That the heat abforbed by elaftic fluids, in their *aërification,* is difengaged when they return to a liquid or folid ftate. 3. That the elafticity of fluids is produced by their abforbing and combining with heat ; and that all aëriform fluids are compound bodies, which owe their form to fixed heat, or the caloric principle, as we have elfewhere fhown.

The muriatic acid abforbs the carbonic acid ; but the reciprocal action of thefe two acids has not yet been properly examined. The muriatic is known to be the ftronger of the two ; for it difengages the carbonic from all its bafes, and enters itfelf into combination with them. Bergman arranges its attractions for the different alkaline bafes in the following order, proceeding from that with which it has the ftrongeft to that with which it has the weakeft affinity : barytes, potafh, foda, lime, magnefia, ammoniac, alumines.

The intimate nature of the muriatic acid, and the principles of its compofition, are unknown. Beccher imagined it to confift of fulphuric acid with *mercurial* earth ; becaufe he had obferved that acid to have a ftrong affinity, and combine very readily, with all the bodies in which he admitted the exiftence of this principle, fuch as arfenic, mercury, &c. Stahl has not illuftrated Beccher's opinion concerning this acid. And among all the ingenious experiments of the moderns, there is none which throws any light on the conftituent principles of the muriatic acid. As its bafe is unknown to us, we cannot determine whether it admits of two ftates of faturation with oxigene ; in one of which, the bafe being completely faturated, the acid muft be

ftronger, while in the other the bafe being combined with a fmaller quantity of oxigene, the acid muft be weaker, according to what has been obferved of the nitric, the nitrous, the fulphuric, and the fulphureous acids. Even the exiftence of oxigene in the muriatic acid has not yet been fully evinced; it is only from analogy that it has been admitted.

Scheele is the only chemift who has done any thing of confequence on this head. In the year 1774, he made an important difcovery concerning the different ftates in which this acid exifts. By diftilling a quantity of muriatic acid upon oxide of manganefe, he obtained this acid in the form of a yellowifh gas, of a very pungent fmell, amazingly expanfive, and capable of diffolving any metal with facility, mercury or gold not excepted. He thought that, in this inftance, the manganefe, which he imagined to be very greedy of phlogifton, abforbed the phlogifton of the muriatic acid; and he therefore called this acid, after it had undergone this operation, *dephlogifticated marine acid;* and thought that it diffolved gold, from its avidity to unite with a new portion of phlogifton. No unequivocal experiment, however, demonftrated the exiftence of the inflammable principle in this acid : and in the year 1780, I fufpected that it was the bafe of vital air contained in the manganefe, which entered into union with the muriatic acid; as may be feen in the firft edition of my Elements under the articles *Aqua Regia* and *Manganefe*, &c. M. Berthollet, my fellow-academician, has fhown that conjecture to be a certain truth, by a feries of accurate and ingenious experiments.

A

· A diſtillation of the muriatic acid on oxide of manganeſe, afforded him yellow vapours without the help of fire. If the retort be heated, and the vapours received in flaſks full of water, and immerſed in ice, a very ſmall portion of the acid is diſſolved, but the water is ſoon ſaturated; after the ſaturation of the water, the reſt of the gas aſſumes a concrete form, and falls in cryſtals to the bottom of the liquor. This ſalt melts, and riſes in bubbles with the moſt moderate heat.

· The oxigenated muriatic acid in a liquid form, or diſſolved in water, has, according to M. Berthollet, an harſh though not an acid taſte; it whitens and deſtroys vegetable colours, without changing them firſt into a red; it neither expels the carbonic acid from its baſes, nor produces any efferveſcence with alkaline ſubſtances ſaturated with that acid; in ſhort, it poſſeſſes not the uſual properties of acids. If heated with quicklime, it efferveſces, and gives out vital air, ſo that the remains is nothing but calcareous muriate; which is evidently produced by the diſengagement of the oxigene with which the acid was ſaturated. The oxigenated muriatic acid produces likewiſe an efferveſcence when it combines with pure ammoniac. The reſult of this combination is, on the one hand, water; on the other, azotic gas. In this inſtance, the oxigenated muriatic acid and ammoniac are both decompoſed; the hydrogene, which is one of the principles of the ammoniac, unites with the oxigene, with which the muriatic acid is ſuper-ſaturated, and by their union the water is formed; while again, the azote, the other principle of the ammoniac, uniting with the caloric, eſcapes under an elaſtic form, and produces the efferveſcent motion

observed

obferved in this experiment. Laftly, the oxigenated muriatic acid converts metals into oxides, and diffolves them without occafioning effervefcence. It deftroys vegetable colours, as it paffes into the ftate of common muriatic acid. All thefe experiments prove, that Scheele's dephlogifticated muriatic acid, is a combination of this acid in a pure ftate, with the bafe of vital air, or the oxigenous principle; and that its proper name is, *aërated or oxigenated muriatic acid*, as I have fhown in my fqrft edition. M. Berthollet has not yet determined what quantity of oxigene the muriatic acid muft abforb, in order to acquire the properties of oxigenated muriatic acid *. In March 1787, he difcovered that oxigenated muriatic gas, received into a lixiviate of cauftic potafh, forms a cryftallifable neutral falt, which, like nitre, or even in a greater degree, produces detonation on burning coals ; affording by the action of the fire very pure vital air, or oxigenous gas, and leaving a refidue of muriate of potafh. Thefe experiments concur to fupport the theory which I offered to the public feven years fince, concerning the nature of the oxigenated muriatic acid ; for the detonation of oxigenated muriate of potafh is plainly owing to its containing an extraordinary quantity of oxigene. Soda forms only a deliquefcent falt with the oxigenated muriatic acid.

The muriatic acid is made ufe of in feveral of the arts, and more efpecially in the art of affaying in the humid way†. In medicine, it is well diluted in wa-

                                                              ter,

* See *Journ. de Phyfique*, tome xxvi. *page* 321, *Mai* 1785.

† See Bergman, de Docimafia humida, Opufc. Vol. II. Or the Fnglifh tranflation of his Opufcula.—H.

ter, and adminiftered as a diuretic, an antifeptic, and a cooler; it is the chief ingredient of the Prior de Cha-briers cure for ruptures. It is externally applied as an efcharotic, to deftroy altered flefh, as a cure for the gan-grene in the throat, aphthæ, &c. Mixed with a certain quantity of water, it compofes a bath for the feet, ufed by fome people, and confidered as a fecret, for draw-ing the gout from the more vital to the inferior parts.

But the oxigenated muriatic acid has been known for too fhort a fpace of time to admit of its being much ufed in the arts. M. Berthollet thinks that it may be fuccefsfully employed for difcovering in a few minutes or hours, what effects the action of air would produce on coloured ftuffs, and thus determining the fixity or alterability of the colours: he has of late recommend-ed it for whitening linen and unbleached yarn: and the firft trials, which have been made in Paris on a pretty extenfive fcale, promife favourably. It may like-wife be advantageoufly employed for whitening in a fhort time the yellow, and more efpecially the green wax from our iflands *.

<div align="center">Species III. *The Fluoric Acid.*</div>

THE fluoric acid, difcovered by Scheele, has recei-ved this name becaufe it is obtained from a fort of earthy neutral falt, with which we fhall afterwards get acquainted under the name of *fluor fpar*.

This acid when pure has a gafeous form, and we

<div align="right">muft</div>

* The oxigenated muriatic acid is now generally ufed in bleaching, in confequence of the experiments of M. Berthollet. By M. Chaptel it is recommended to make old books and manufcripts legible. In its concrete form, it is cryftallifed into quadrangular prifms, truncated very obliquu-y, and terminated by a lozenge.—H.

muft examine its properties as it exifts in that ftate.
The fluoric acid is more ponderous than common air.
It extinguifhes lights and kill animals. It has a pun-
gent penetrating fmell, nearly the fame with that of the
muriatic acid gas, but rather lefs keen. Its caufticity
is fuch that it corrodes the fkin, however fhort the
fpace of time during which it is expofed to its contact.
It fuffers no fenfible alteration from light. Heat dilates
it, but without changing its nature.

The water contained in atmofpheric air, enables it to
deftroy the tranfparency of the fluoric acid, and convert
it into a white vapour; which it does more or lefs readi-
ly, according as it contains a greater or a lefs quantity
of water. This phenomenon refembles that which the mu-
riatic acid prefents on the fame occafion; but the vapour
of the fluoric gas is thicker than that of the other.

The fluoric acid gas unites eagerly with water, and
heat is produced at the inftant of their union. A pecu-
liar phenomenon appears on this occafion, namely, the
precipitation of a very fine white earth, which appears
to be filiceous earth. From this circumftance it ap-
pears that the acid is far from being pure in the ftate
of elaftic fluidity. It becomes pure, therefore, only
when the earth, which adhered to it when it was vola-
tilized, has been feparated by the action of water. A
folution of this gas in water conftitutes the acid fpirit
of fluor; the fmell and caufticity of which are very
ftrong, when the water is faturated with it. This liquid
acid communicates a ftrong red colour to the fyrup of
violets. According to Scheele and Bergman, it poffef-
fes the fingular property of diffolving filiceous earth.
Although the fluoric acid gas, on uniting with wa-
                                            ter,

ter, depofite a confiderable quantity of this earth, yet it ftill retains fo much that alkalis caufe it to afford a new precipitate.

Dr Prieftley obferved, that the fluoric acid gas corroded and penetrated common glafs, and found it neceffary to ufe thick glafs bottles for his experiments. Macquer thought that the acid produced this effect only when in a gafeous ftate, but was incapable of attacking glafs when liquid or diluted in water. This opinion is founded on the circumftance of water's precipitating the filiceous earth, which is maintained in a ftate of folution in the fluoric gas. But it is to be remembered, that the water does not entirely feparate the earth from the acid ; and therefore the fluoric acid muft retain, even in a fluid ftate, the power of acting on glafs and filiceous ftones.

The liquid fluoric acid may be decompofed like fpirit of falt by heating it in a retort, the extremity of which enters a bell-glafs full of mercury. By this means the acid is obtained in gas, and leaves the water pure.

The two French chemifts who, in the year 1773, publifhed, under the name of M. Boullanger, a feries of experiments on the vitreous fpar, or the fparry fluor, are of opinion that the acid of this fpar is nothing but a combination of muriatic acid with an earthy mat. ter, which water only is capable of feparating from it. But Scheele has fuccefsfully combated this opinion· He confiders it as a peculiar acid, ftrikingly diftinguifhed from all others by the various combinations of which it is fufceptible. And his opinion is at prefent very generally received among chemifts.

The fluoric is the only mineral acid capable of dif-

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folving filiceous earth. Bergman and Scheele were of opinion, in the year 1779, that this earth might very probably be a compound of the fluoric acid with wa-ter; becaufe the fluoric acid gas depofites no fmall quantity of filiceous earth, when brought into contact with water. But an experiment of M. Meyer's has fince proved, that the earth precipitated on that occa-fion comes from the glafs veffel, part of which is dif-folved by the acid. That chemift took three cylindri-cal tin veffels, into each of which he put an ounce of *vitreous fpar* and three ounces of fulphuric acid, which having a greater affinity than the fluoric acid with lime, is fuccefsfully employed to feparate this latter acid: to one of thefe mixtures he added an ounce of pulverized quartz; to the fecond an ounce of powder of glafs; the third he left pure without any addition: in each of the cylinders he hung a wet fponge, and clofing up the veffels, expofed them to a moderate temperature. Half an hour after, he found a filiceous duft depofited on the fponge of the mixture containing the glafs; at the end of twelve hours, the fponge of the veffel containing the quartz was likewife covered over with an earthy incruftation ; but even af-ter feveral days the fponge of the third veffel exhibited no fuch appearance. Bergman fent an account of this experiment to M. de Morveau, letting him know at the fame time, that he now gave up his opinion concern-ing the formation of filiceous earth by the combination of the fluoric acid gas with water. The precipitation is therefore owing to the glafs diffolved by the fluoric acid gas ; and the acid is not pure till after the precipi-tate has been feparated from it by water and alkalis.

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The fluoric acid, either in a gafeous or a liquid ftate, unites with aluminous earth, forming with it *aluminous fluate**, a fweet tafted neutral falt, which readily affumes the confiftency of a thick jelly.

It combines alfo with barytes: the falt refulting from this combination, to which we give the name of *barytic fluate,* is a pulverulent fubftance.

With magnefia the fluoric acid forms a cryftallifable falt, *magnefian fluate.*

It forms a precipitate with lime water, producing inftantly *calcareous fluate.*

It combines with potafh to form *fluate of potafh;* with foda, it produces *fluate of foda;* laftly, combining with ammoniac, it forms the falt which we call *ammoniacal fluate.*

This fhort account of thefe faline combinations fhows the fluoric acid to be evidently different from the muriatic. Its affinities with the different bafes afford new proofs in fupport of the fame truth. Bergman obferves, that the fluoric acid, when united with potafh, may be feparated from it by lime-water, which caufes the folution of that falt to afford a precipitate. The fame thing takes place on a folution of the barytic fluate, which becomes muddy when lime is put into it. Bergman gives its elective attractions in the following order; lime, barytes, magnefia, potafh, foda, ammoniac: but he confeffes that more experiments are neceffary to eftablifh fully this order of affinities.

* According to the methodical nomenclature which we have propofed, the word *fluorate* is here to be ufed; but we contract it into *fluate:* and we fhall do the fame for the fulphuric acid, ufing *fulphate* inftead of *fulphurate.—F.*

The fluoric acid gas has not as yet been applied to any purpofe in the arts : but its power of diffolving filiceous earth, will in all probability render it very ufeful in chemical operations, when proceffes for obtaining it more conveniently than at prefent, fhall have been introduced.

Species IV. *The Nitric Acid.*

What is called *fpirit of nitre* in the laboratory, is a combination of this acid with water. In a liquid ftate and pure, the acid is white ; but if altered in the fmalleft degree, it becomes yellow or red ; and there arifes from it in great abundance a vapour of the fame colour. It is fo cauftic that it burns and deftroys inftantaneoufly the organization of the mufcles. It reddens fyrup of violets, and entirely deftroys its colour.

On being expofed to the rays of the fun, it acquires according to Scheele, an higher colour and greater volatility ; and from this it appears that light acts upon it: As it acquires a deeper colour, vital air is difengaged from it.

Heat volatilizes this acid, and feparates the colouring matter in the form of red vapours.

When red, it unites eagerly with water, which affumes in confequence, a green or blue colour : it appears to have acquired a confiderable degree of heat in entering into this combination. When united with a large quantity of the fluid, it forms *aquafortis.*

The white and the red nitrous acids were formerly confidered as being of the fame fubftance, only concentrated

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:ed in different degrees; the higher coloured was
ught to be the moft concentrated of the two. But
are now better acquainted with the nature of this
ne fubftance, and krow it to be capable of exifting
two different ftates. In one of thefe the acid of nitre
leftitute of colour, more ponderous, and lefs vola-
:, and emits only a white fmoke; in the other, it is
a colour varying in fhade from a yellow to a brown
l, is more light and volatile, and is conftantly emit-
; red vapours, in greater or lefs abundance, accord-
; to the temperature to which it is expofed. Berg-
n diftinguifhes between thefe two ftates of the acid
nitre, by giving to the one the name of *dephlogifti-
ed*, to the other that of *phlogifticated;* we give to
: former, the white, the name of the *nitric acid;* to
: coloured, the name of the *nitrous acid.* The caufe
thefe diftinctions will hereafter be fhown: Only, we
y here obferve, that if the coloured and fuming ni-
us acid be diftilled in a glafs retort, the red part
:s firft off in vapour, and what remains is a white
d colourlefs acid. The darker the colour of the fpi-
of nitre fubjected to diftillation, fo much the greater
the quantity of the vapours obtained, and fo much
: lefs the portion of the white acid remaining in the re-
t; and *vice verfa*, when the nitrous acid heated in
: retort is of a bright red colour, very little vapour,
t a great deal of the white acid is obtained. This
tance fhows the red acid to be more volatile than
: white. And as all coloured fpirit of nitre is com-
unded of the two, they are to be feparated by a pro-
s cf diftillation judicioufly conducted. In this ope-
ion a certain quantity of vital air is always difenga-

ged, which may be collected by applying a pneumato-chemical machine to a balloon. We muft remark, that when the veffels are red-hot, certain red vapours are conftantly feparated even from the whiteft nitric acid; and the colour of the acid is alfo changed, fo that it be-comes of a flame-red : But the change produced by heat 'immediately difappears when the acid returns to its former temperature, and the vapour alfo returns to a liquid. The fame thing happens when a portion of the nitrous acid, highly coloured, is united with water; a red vapour is difengaged and paffes into the atmo-fphere; the heat which then takes place, increafes the colour of the acid which had been weakened by the water; what remains after tne evaporation is not ni-trous, but nitric acid; and the change is inftantaneous. When heat, by the affiftance of, light, produces this change on the nitric acid, a quantity of vital air or oxi-genous gas is difengaged, proportioned to that of the nitrous gas which is formed on the occafion. This de-compofition of the nitric acid, and the change of it in-to the nitrous, takes place in confequence of the mu-tual affinities between light, caloric, and oxigene. In this inftance the glowing heat of our veffels acts like that of the rays of the fun.

The nitric acid acts not upon filiceous earth : it com-bines with alumines, with barytes, with magnefia, with and with lime, the three alkalis: with thefe fubftances it forms the aluminous, barytic, magnefian, and calcareous nitrates, nitrate of potafh, nitrate of foda, and ammoniacal nitrate. All thefe falts fhall be hereafter particularly examined. The falts formed by the union of the fame bafes with the nitrous acid are fomewhat different from

thefe,

efe, and are diftinguifhed in our methodical nomen-
ature by the name of *nitrites.*

The nitric unites with the carbonic acid, abforbing
eagerly. The mutual action of thefe two bodies is
ıt yet well known.

The nitric enters very rapidly into combination with
e muriatic acid. The alchemifts gave the name of
ıxa *regia* to this compound, becaufe they ufed it to
ffolve gold, the king of metals : we fhall henceforth
ll it the *nitro-muriatic acid.* It muft have always
ıpeared fingular, that two acids, neither of which is
ı itfelf capable of acting upon gold, fhould by combi-
ıtion acquire the power of diffolving it. The alche-
ifts, content with having found a folvent for that
ecious metal, gave themfelves no concern about the
ufe of the phenomenon. It is but a few years fince
ıo Swedifh chemifts, Scheele and Bergman, firft
ıght to difcover what alterations the nitric and the
ıriatic acids produced on each other by mutual com-
ıation. Scheele obferved, what we have already ta-
n notice of, that by diftilling a portion of muria-
  acid on calx or oxide of manganefe, the acid
ıs caufed to diffufe a yellowifh vapour of the fame
ell with *aqua regia,* which deftroyed blue vegetable
lours, and acted with a powerful force upon metals,—
ıre efpecially upon gold, which it diffolved as well
the nitro-muriatic acid. He thought that it acqui-
l thefe properties in confequence of being deprived
its phlogifton by the oxide of manganefe, and that
ıat caufed it to act fo forcibly on combuftible bodies
s its eagernefs to regain the principle which it had

loft. For this reason he gave it the name of *de-phlogifticated marine acid.* Our first obfervation here is, that this explanation of thefe phenomena is direct-ly contradictory to the theory of Stahl, which Scheele in general appears to have adopted and extended : for the muriatic acid is faid to acquire, by the lofs of its phlogifton, a fet of properties which Stahl attributed to the prefence of that principle ; namely volatility, a ftrong fmell, and a power of acting on inflammable matters. Befides, we are of opinion, that all thefe phenomena may be much more fatisfactorily explain-ed by the new theory : and this we fhall very foon fhow.

Bergman thinks that the nitric acid feizing on the phlogifton of the muriatic acid, is partly diffipated in-to vapour, and that what remains of the muriatic acid is then precifely in the fame ftate with the vapour which arifes from the diftillation of this acid on oxide of manganefe. Thus, what enables the nitro-muriatic acid to diffolve gold, is its containing a portion of *de-phlogifticated marine acid :* and this mixed acid is of-ten nothing but marine acid. Such is the opinion of the celebrated chemift of Upfal. The following ap-pears to me a better account of the facts. When a quantity of nitric acid is poured upon a quantity of muriatic acid, heat is excited between the two li-quors, and they affume a colour ; an effervefcence takes place, and a kind of mixed fmell arifes, not fo pun-gent as that of the muriatic acid, but quite peculiar, and refembling that which this acid affords when diftil-led on oxide of manganefe. · Mr Berthollet has difco-vered, that a portion of oxigenated muriatic acid is difengaged during this rapid re-action of the two acids.

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On this occafion, therefore, the muriatic acid deprives the nitric of part of its oxigene, and is diffipated in the form of oxigenated muriatic gas; yet a portion of it ftill remains faturated with oxigene and nitrous gas; and this mixture is *aqua regia*. From this we under- ftand why fo fmall a proportion of the nitric acid is neceffary to communicate to the muriatic the proper- ties of aqua regia; and why both the nitro-muriate of gold, and the nitro-muriatic acid, afford when diftilled nothing but muriatic acid. But we muft obferve, that, as much more nitric acid than is neceffary, is generally ufed to fúper-faturate the muriatic acid with oxigene, the nitro-muriatic acid which refults from this compofi- tion contains both acids, and they act each according to its peculiar nature, forming peculiar and diftinct falts with all the bodies expofed to their action. It would therefore be a fervice of fome importance to chemiftry, to determine what quantity of the nitric acid is neceffa- ry to faturate a given quantity of the muriatic with ox- igene, and to caufe it to affume the character of nitro- muriatic acid, without containing any aquafortis, which only alters it and renders its effects uncertain. Hence it appears neceffary, in recording accurate chemical ex- periments upon this matter, to mention the proportion in which the two acids have been mixed to produce the *aqua regia* made ufe of.

This mixed acid has lefs fpecific gravity than either of the two acids of which it is compofed. It has a peculiar fmell, commonly a citron-colour, often inclin- ing to orange. Its action on natural bodies diftin- guifhes it from all other acids. Light extricates from it a portion of oxigene gas or vital air. Heat feparates

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from it oxigenated muriatic acid. *Aqua regia* combines with water in any proportion, and always excites heat as it enters into combination with that fluid. It diffolves alumine, but very flowly : it unites with barytes, magnefia, lime, and the alkalis; and from thefe combinations there refult mixed falts, which cryftallize either feparately or together, according as they are more or lefs foluble. *Aqua regia* is much ufed both in chemiftry and in the art of affaying ; as we fhall fhow more at large when we come to fpeak of metallic fubftances.

Since the æra of Dr Prieftley's difcoveries, chemifts have laboured much to difcover the intimate nature and the component principles of the nitric acid. It was fhown, in the firft place, that the opinion which afcribed the formation of the nitric to the fulphuric acid, and reprefented the former as a modification of the latter, was founded on fallacious experiments. Soon after, it was obferved, that this acid is formed of peculiar principles ; and the following obfervations led to a certain difcovery of its nature.

The nitric acid had been long obferved to act with great force on combuftible bodies, more efpecially on the metals. On fuch occafions, it exhales into the atmofphere a confiderable quantity of red vapours, and is often indeed entirely diffipated under this form. The combuftible body expofed to its action is foon reduced to the ftate of a burnt body, or oxide ; nay, it often caufes combuftible bodies, fuch as oils, charcoal, fulphur, phofphorus, and feveral of the metals, to emit a fudden flame. Stahl afcribed this effect to the rapidity with which the acid combined with the phlogiftion of

combuftible

combuftible bodies. But this theory did not afford a fatisfactory explanation of the phenomenon.

Dr Prieftley, by receiving into a glafs veffel filled with water, the vapour difengaged during the action of the nitric acid on a piece of iron, obferved, that inftead of a red vaporous fluid, a tranfparent colourlefs gas re-fembling air was obtained on that occafion; and to this he gave the name of *nitrous gas.*

This gas poffeffes all the apparent properties of air, but differs greatly from it in refpect to chemical pro-perties. It has rather lefs gravity, is unfit for main-taining either combuftion or refpiration, is ftrongly antifeptic, has no fenfible tafte, and takes a long time to alter the colour of fyrup of violets. Nitrous gas appears to fuffer no alteration from light. Heat di-lates it. Vital air readily combines with it; thus re-ducing it to the ftate of nitrous acid. Atmofpheric air produces the fame effect upon it, but not fo forcibly. This combination difplays feveral phenomena which well merit our attention. As foon as air comes into contact with nitrous gas, though both the fluids were before colourlefs, they become inftantly red like the nitrous acid: a pretty lively heat is then excited; the water rifing in the receiver abforbs all thefe red vapours, and thus acquires the character of aquafortis. The purer the air is, the more readily do thefe phenomena take place, the more ftriking do they appear, and the fmaller is the proportion neceffary to change a given quantity of nitrous gas into nitrous acid. M. Lavoifier has difcovered, that fixteen parts of atmofpheric air are neceffary to faturate feven and one-third of nitrous gas, while four parts of vital air are fufficient for the com-

plete faturation of the fame quantity of the fame gas. Macquer thought this beautiful phenomenon precifely fimilar to combuftion. It is in fact accompanied with heat, the abforption of air, and the production of a fa: line matter; and the red colour which then appears may be confidered as a kind of flame.

As in this artificial compofition of the nitrous acid, the air produces different effects, according as it is more or lefs pure, Dr Prieftley thinks that nitrous gas may ferve as a teft to enable us to diftinguifh what quantity of vital air any other kind of air contains; if we affume as two terms,—the moft impure air, or gas unfit for re-fpiration, fuch as the carbonic acid, which produces no change whatever on nitrous gas,—and vital air, which produces the greateft alteration upon it. This affay confifts in employing known and proportional quanti-ties of thefe two gafes, and obferving when they are mutually and completely faturated. That air is the pureft of which the fmalleft quantity is fufficient to faturate a given quantity of the nitrous acid, and *vice verfa.*

Several philofophers have endeavoured to find means for performing this experiment with the moft rigid accuracy. The Abbé Fontana has been the moft fuc-cefsful: he has contrived an *eudiometer*, of which an ex-act defcription is to be found in M. Ingenhoufze's experi-ments on vegetables. By means of that inftrument, the degrees of the purity or impurity of the air may be eftimated with the utmoft nicety; but, as the author himfelf acknowledges, fuch fkill and attention are ne-ceffary in making ufe of it, that to avoid miftakes and erroneous calculations is exceedingly difficult.

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It is farther of confequence to obferve, that thefe experiments, though extremely ingenious and of confiderable utility, have not been attended with all the advantages expected from them, in regard to that branch of medicine, the object of which is the prefervation of health. They fhow what quantity of air fit for refpiration is contained in that under examination; but they afford no information concerning the manner in which the noxious qualities of this fluid affect the feveral parts of the human fyftem with which it is brought into contact by refpiration ; they explain not how it acts on the ftomach, the fkin, or the nerves; all of which are affected by almoft every alteration of the air, though only medical obfervations can inform us in manner.

Chemifts have for a number of years been divided in their opinions concerning the caufe of the production of the nitrous acid from the mixture of nitrous gas with vital air. Dr Prieftley, the difcoverer of the fact, is of opinion, that nitrous gas is merely nitrous acid fuperfaturated with phlogifton ; and that as pure air has a greater affinity than the acid with phlogifton, it therefore, entering into combination with it, leaves the nitrous acid in a ftate of liberty. But this theory is far from affording a complete explanation of the phenomenon : for when the elaftic fluids with which the experiment is performed are very pure, there is abfolutely no refidue left ; and befides, the nitrous acid formed during the procefs, weighs confiderably more than the portion of nitrous gas which was made ufe of to produce it.

M. Lavoifier imagined that this property of nitrous gas—to produce nitrous acid, when brought into con-

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tact with vital air, might lead him to a knowledge of the component principles of the acid. By combining two ounces of fpirit of nitre of known ftrength, with a given quantity of mercury, he obtained 196 cubic inches of nitrous gas, and 246 cubic inches of vital air. While the former gas was difengaged, the mercury changed its form ; after the vital air was difengaged, it returned to a metallic ftate, when it was found to have fuffered no lofs. From thefe facts he deduced the following inferences with great accuracy of reafoning. —1. As the mercury fuffered no lofs during the procefs, the formation of the elaftic fluids cannot be afcribed to it. 2. Thefe muft therefore have been formed by the decompofition of the nitrous acid. 3. The nitrous acid made ufe of on the occafion, the gravity of which was to that of diftilled water as 131,607 to 100,000, appears therefore to have been formed of three principles, nitrous gas, vital air, and water, united in the following proportions to the pound: nitrous gas, 1 ounce 51½ grains; of vital air, 1 ounce 7 drams 2½ grains; and of water 13 ounces and 18 grains. 4. Nitrous gas is nitrous acid deprived of its oxigene or vital air. 5. In all proceffes in which nitrous gas is obtained, the nitric acid is decompofed, and its oxigene abforbed, by the combuftible body with which it has a greater affinity.

Yet this opinion is attended with one difficulty. M. Lavoifier found that he could not reproduce by the reunion of thefe products the whole quantity of the acid from which they were obtained; at leaft one half was entirely loft: and he had much more pure air than was neceffary for the complete faturation

the nitrous gas. He acknowledges himfelf unable to
account for this circumftance. Macquer imagined it
to depend on the lofs of the phlogifton, or light, which
he confidered as one of the principles of the nitric acid :
this he thought might efcape through the pores of the
veffels during the decompofition of the acid, leaving
behind part of its pure air, which being lefs fubtle,
could not make its way out with the fame facility. We
fhall foon fee this not to be the true caufe of the phe-
nomenon.

The portion of fuperfluous gas which remains after
the nitrous gas has been faturated with vital air, ftill
remained an objection againft M. Lavoifier's theory.
And though this fuperfluity was quite a trifle in this
experiment, as 7½d parts of nitrous gas, with 4 parts
of vital air, left no more than $\frac{1}{12}$th of their total bulk;
yet ftill he was at a lofs how to account for it. In-
deed he has fince informed us, that the refidue was
much lefs when the matters made ufe of were very
pure and very nicely proportioned. In fhort, we fhall
immediately fee that vital air and nitrous gas may be
obtained fo pure as to combine without leaving any re-
fidue.

No fuch difficulty occurs in confidering the aëriform
refidue formed by the combination of 16 parts of at-
mofpheric air with 7½d of nitrous gas: we know it to
be the mephitis or gas azote contained in the atmof-
pheric air. We underftand likewife how the contact
of water comes at length to alter nitrous gas and
change it into an acid : it is by means of the air which
it contains.

But even after this theory of M. Lavoifier's, the na-

ture of nitrous gas ftill remained unknown ; and it
has fince been explained by a fine experiment of Mr
Cavendifh's.   This chemift put into a glafs tube feven
parts of vital air not obtained from the nitric acid,
with three of gas azote or atmofpheric mephitis ; and
by caufing the electric fpark to pafs through the mix-
ture, he effected a great diminution of its bulk, and
even changed it into nitric acid.   The induction which
he draws from thefe facts is, that the nitric acid is a
combination of feven parts of vital air to three of gas
azote ; and that, when deprived of a part of the firft
of thefe principles, as happens in the folution of me-
tals, &c. it paffes into the ftate of nitrous gas : Nitrous
gas, therefore, is, in his opinion, nothing more than a
combination of gas azote with a fmaller proportion of
vital air than what is requifite to form nitrous acid.
Thefe experiments, and the ingenious theory founded
upon them, throw great light on the formation of the
nitric acid by the putrefaction of animal matters.   We
know that a great quantity of gas azote is difengaged
from thefe matters when putrefying ; and it is evident
how neceffary vital air is for the production of this acid,
as experience fhows it to be formed by the combination
and fixation of thefe two elaftic fluids.

It is alfo eafy to determine the difference between
the pure white acid of nitre and the coloured fuming
acid to which the northern chemifts·give the name of
phlogifticated ; or between the nitric and the nitrous
acids.   The laft is found where the principles are not
combined in the proportion proper for forming the
pure nitric acid,—that is, when the combination con-
fifts not of three parts of azote and feven of oxi-

gene.

gene. But as a variety of circumftances, and in general all *phlogifticating* procefles, diminifh the proportion of the oxigene, by wafting more or lefs of it, hence we may naturally infer, 1. That this acid is very liable to alteration, and muft often be more or lefs coloured and fuming: 2. That in proportion as it is deprived of more or lefs of its oxigene, it may pafs through many ftates, from that of the pureft nitric acid, which contains the greateft proportion of oxigene,, to nitrous gas, which contains not enough to conftitute it an acid: 3. That if nitrous gas be deprived of what oxigene remains in it, it becomes gas azote or mephitis: 4. That as the mutual adhefion of the oxigenous and azotic principles is very trifling, moft combuftible bodies having a greater affinity with the former than the azotic principle has; the nitric acid cannot but be decompofed with great facility by many bodies. Thefe four remarkable particulars in the hiftory of the acid of nitre, ferve to explain a great many phenomena. We now underftand, 1. That in this acid the gas azote and vital air have loft much of their caloric, and are therefore reduced to azote and oxigene. 2. That when this acid is decompofed by a combuftible body, the nitrous gas then difengaged does not require fo much caloric to maintain it in a ftate of elaftic fluidity, as vital air and gas azote. 3. That thefe two fluids cannot combine when in a gafeous ftate. 4. That of confequence the vital air obtained from nitrous preparations ftrongly heated, fuch as *red precipitate*, nitrate of lead, common nitre, &c. muft contain a certain proportion of mephitis or azotic gas; of which gas, the refidue, remaining after the union of the vital air

with

with the nitrous gas, confifts. No fuch refidue is ever obferved to remain, when the vital air made ufe of, has been obtained from the leaves of vegetables or from manganefe. 5. That the cafe is fometimes the fame with nitrous gas; it may contain a portion of gas azote or mephitis: and this happens when this gas is prepared with bodies which, being very greedy of oxigene, abforb it almoft entirely from the nitric acid; fuch as iron, oils, &c. 6. That the nitrous acid when coloured, and containing an excefs of nitrous gas or of azote, or the bafe of mephitis, is in a ftate very different from that in which the two principles are no more than mutually faturated; and that as the difference between thefe two ftates of this acid is fo very confiderable, they fhould therefore be diftinguifhed by different names. To the white acid, which, though the moft uncommon, *is* the pureft, we give the name of the *nitric acid*, obferving the fame analogy in this as in the reft of our new denominations; and to its neutral falts we give the name of *nitrates*. The red again we call *the nitrous acid*, and its faline combinations *nitrites*. There is indeed but feldom occafion to fpeak of the laft of thefe claffes of neutral falts: for though the red and fuming, or the nitrous, be the moft common of the two acids, it very feldom retains its proper character when united with alkaline bafes; the fuperfluous quantity of the nitrous gas ufually efcapes as the combination is taking place, and what remains is pure nitric acid.

The affinities of the nitric acid with the alkaline bafes are the fame as thofe of the muriatic; and Bergman arranges them in the fame order, as follows,—

barytes,

barytes, potafh, foda, lime, magnefia, ammoniac, alu-
minous earth. According to that celebrated chemift,
the nitrous or *phlogifticated* acid has the fame affinities
as the pure acid of nitre. It is ftronger than any of
the preceding acids, and difengages the carbonic, fluo-
ric, and muriatic acids, from their bafes.

The acid of nitre, under the name of *aquafortis*, is
applied to a great many purpofes in the arts ; more
particularly, it is ufed to diffolve mercury, copper, fil-
ver for hatters, engravers, and gilders, in affaying and
working metals, &c. It is likewife ufed in furgery,
to deftroy warts and other little indolent uninflamed
tumours. It is ufed in many pharmaceutical prepara-
tions, fuch as *mercurial water*, *red precipitate*, *the alka-
line martial tin{\it}ure*, *the yellow unguent*, &c. &c. We
fhall take notice of thefe and the other ufes to which
it is applied in their proper places.

Species V. *The Sulphuric Acid.*

THE fulphuric acid, which has hitherto been called
the *vitriolic acid*, is a very cauftic faline fubftance,
which, when concentrated, burns and cauterizes the
fkin, reddens fyrup of violets without deftroying its
colour, and when diluted in a large proportion of wa-
ter, has a four, ftiptic tafte. This acid, when pure,
appears under the form of a very tranfparent oleagi-
nous fluid, twice the fpecific weight of diftilled water,
deftitute of fmell, and united with water, from which
there are as yet no means known of feparating it. It
has received the name of the *vitriolic acid*, becaufe it
ufed formerly to be obtained from martial vitriol by

diftillation. At prefent it is obtained both in France
and England by the complete combuftion of fulphur,
as we fhall explain more at large when we come to
give the hiftory of that combuftible fubftance. Its
nature, therefore, and the manner in which it is ob-
tained, render it moft proper to give it in a methodical
and regular nomenclature, the name of the *fulphuric
acid.*

When highly concentrated, it is from its confiftency
named very improperly *oil of vitriol.*

This acid is fufceptible of a concrete form ; which it
may be made to affume either by expofing it to cold, as
we fhall afterwards fee, or by combining it with vari-
ous elaftic fluids.

We know not yet, in what manner light acts on the
fulphuric acid. Some chemifts have afferted, that
when oil of vitriol is expofed in clofe veffels to the rays
of the fun, it gradually affumes a colour, and there is
even fome fulphur formed. But this fact is not alto-
gether eftablifhed by proofs; nay, there is even a
ftrong probability againft it; for we fhall hereafter fee,
that the fulphuric acid cannot become fulphur without
lofing its pure air or oxigene ;—and it is evident that
fuch a feparation cannot take place in clofe veffels,

Stahl thought the fulphuric acid to be diffufed through
all nature, and to be the principle of all other acids.
The firft of thefe affertions was founded on this fact,
that linen impregnated with potafh, and expofed to
the air, is at length converted into fulphate of potafh;
that is, into a neutral falt formed by the union of the
alkali with the fulphuric acid. This affertion is at pre-
fent known to be falfe ; for fuch linen contains not an
atom

atom of fulphate of potafh, but a good deal of carbonate of potafh, or the combination of this alkali with the carbonic acid. With refpect to the fecond, nothing can be more improbable. Late experiments have fhown that each of the acids is formed of peculiar principles ; and that there is no principle common to one with another of them, but the bafe of vital air, which is common to them all.

The fulphuric acid, when heated in a retort, foon lofes part of its water, is in fome degree concentrated, and is not volatilized unlefs expofed to a ftrong heat. If coloured, it lofes its colour by the action of the fire, and becomes white. This *double* change which it undergoes at *one* time, is called the *concentration* and *rectification* of the acid. While it is taking place, a very odorous and penetrating gas is difengaged, which was the colouring principle of the acid, and with which we fhall afterwards get acquainted under the name of the *fulphureous acid gas.* Although this procefs appear to render the fulphuric acid whiter and more pure, yet it muft be carried farther when we wifh to obtain the acid in its higheft purity : in fact, in this ordinary concentration, we only free the acid of the water and the fulphureous acid gas united with it, without feparating any of the fixed matters, by which it may likewife be altered : To effect this, we muft diftil the acid to drynefs, by changing the receiver, after performing the firft part of the operation : there remains then in the retort a fmall quantity of a white refidue, which is found to contain fulphate of pot-afh, and fome other fubftances which are diffolved in the acid as it is formed.

The

The concentrated fulphuric acid attracts moifture, when expofed to the air, and lofes part of its ftrength and caufticity : it at the fame time affumes colour, deriving it from the combuftible matters which float in the atmofphere, on which this acid acts with no fmall force.   It often abforbs nearly twice its own weight of water from the atmofphere.

The Duke d'Ayen, by a feries of curious experiments, performed during the violent cold in the month of January 1776, has fhown, that this acid, when highly concentrated, may be made to freeze by expofing it to the cold temperature of from 61° 15', to 65° 45'; but when diluted in two or four parts of water, is no longer liable to the fame change of ftate by cold : and that if when frozen it be left expofed to the air, it foon becomes fluid, even though the cold be more intenfe than that which caufed it to freeze.   This laft phenomenon is owing to its abforbing water from the atmofphere, and to the heat produced while the two are entering into combination.

The fulphuric acid unites with water, difplaying, as it enters into union with it, all the phenomena of a fudden penetration and an intimate combination.   It produces at the fame time a lively heat and a fort of hiffing ; a peculiar fetid odour is likewife difengaged. The hiffing noife excited on this occafion is owing to the difengagement of the air contained in the water, which is feen to make its way out in the form of little bubbles. The tafte of the acid, when thus diluted in water, is much weaker than in its concentrated ftate, its fluidity is much more confiderable, and it now bears the name of *fpirit of vitriol*.   The water may be volatilized by heating

it;

it ; and it may be thus reftored by concentration to the ftate of ·concentrated fulphuric acid.

This acid acts not in any manner on filiceous earth or quartzofe ftones, nor on ·the fame earth when melted with the admixture of fmall pieces of the fixed alkalis. It combines with aluminous earth, barytes, magnefia, lime, and alkalis. In thefe combinations it forms aluminous fulphate, or *alum ;* barytic fulphate, or *ponderous fpar ;* fulphate of magnefia, or *Epfom falt ;* fulphate of lime, or *felenite ;* fulphate of potafh, or *vitriolated tartar ;* fulphate of foda, or *Glauber falt ;* and ammoniacal fulphate. Its elective attractions for thefe falts are the fame with thofe of the muriatic and the nitric acids; but it adheres more firmly to thefe fubftances than any of the other mineral acids ; and is capable of difengaging them.

The action of the fulphuric on the other acids has not as yet been properly examined ; we know only, 1. That it abforbs great quantities of the carbonic acid, 2. That it unites fo readiiy with the muriatic acid, that when we mix the two together, heat is excited, and a great quantity of muriatic acid gas .is difengaged in white vapours. Boerhaave, in his Chemiftry fays, that the muriatic acid renders *oil of vitriol* concrete : perhaps this property may be found to belong to the oxigenated muriatic acid. 3. That if the pure white nitric acid be poured on a quantity of fulphuric acid blackened by fome combuftible body, it deprives it of its colour, and renders it tranfparent; and when this mixture is heated, it exhales a quantity of nitrous gas. 4. That nitrous gas when united with this acid, has the power of making it affume a concrete form ; as

will

will be fhown more particularly in the article of the de-
compofition of nitrate of potafh by means of fulphate of
iron.

The manner in which the fulphuric acid acts on
combuftible bodies, leads us to an idea of its nature and
component principles. Whenever any combuftible
body, fuch as a metal, or ftill more a vegetable or an
animal matter, is brought into contact with the con-
centrated fulphuric acid, that body paffes fooner or la-
ter into the ftate of a burnt matter, and the acid is de-
compofed.

All matters containing oil, become black, if immer-
fed in fulphuric acid concentrated and cold. The
acid firft affumes a brown colour, which foon paffes
into a black. If an inflammable fubftance in combuf-
tion, fuch as a burning coal, be immerfed into a quan-
tity of fulphuric acid, the acid immediately affumes
the fmell and volatility of burning fulphur ; a white
fmoke arifes from it, of a lively fuffocating fmell. If,
in order to comprehend better what paffes when thefe
combinations take place, we bring this acid into con-
tact with fome combuftible body of a more fimple cha-
racter than organic fubftances, whofe alterations may
be more eafily traced and eftimated, we may then at-
tain a knowledge of the principles of the fulphuric a-
cid. If we heat for this purpofe a mixture of this acid
concentrated, with mercury, in a glafs retort, the ex-
tremity of which enters a bell-glafs filled with this metal-
lic fluid ; as foon as the acid is brought to boil, it emits
a permanent gas of a ftrong pungent fmell, refembling
that of burning fulphur.

The aëriform fluid is known by the name of
fulphureous |

fulphureous acid gas : it is fomewhat more ponderous
than air ; it extinguifhes light, kills animals, reddens
and difcolours fyrup of violets. According to Dr Prieft-
ley, it enters into combination with water with lefs
rapidity than the muriatic acid gas ; it diffolves chalk,
camphor, and iron ; coals, and all bodies that are po-
rous in any confiderable degree, abforb it. Though it
has been confidered as a permanent gas, yet by the ap-
plication of an intenfe cold, it may be condenfed fo as
to become liquid. M. Monge accomplifhed this..

The fulphureous is a certain modification of the ful-
phuric acid, which combines with the alkalis to form
neutral falts different from thofe which they form with
the latter. Stahl, who had obferved all of thefe im-
portant phenomena with great attention, thought, that
in this inftance the phlogifton of the metal, uniting
with the acid, communicated to it odour, volatility,
&c. But as that great chemift did not carry his expe-
riments far enough, he could not forefee, that a ftrong
objection againft this doctrine might be drawn from the
very fact on which it was founded. M. Lavoifier, M.
Bucquet, and myfelf, have each of us examined the
confequences of this reciprocal action of mercury and
the fulphuric acid. When the mixture is white and
dry, but a very fmall quantity of fulphureous acid gas
is formed ; if this mercurial fulphate be then ftrongly
heated, a little water, and a gas quite different in na-
ture from the former, are difengaged ; the gas is very
pure vital air. While this gas efcapes from the mix-
ture, the mercury is gradually *reduced,* and regains all
its original properties, not fo much as an eighth part
of its quantity being loft. From this it appears, that

as the mercury has fuffered nó alteration, the two
gafes muft belong both to the fulphuric acid which
has been decompofed. The fulphureous acid gas ap-
pears therefore to bear the fame relation to this acid
which the nitrous bears to the nitric acid. Yet the
compofition of thefe two acids is not made quite in
the fame manner ; for we cannot inftantly re-unite the
two gafeons principles of the fulphuric acid into the
compound body from which they are obtained ;
whereas we can form the nitrous acid at pleafure, by
combining the nitrous gas, and the vital air which it
affords when analyfed. It is very likely that a confi-
derable fpace of time is neceffary for the recompofition
of the fulphuric acid : for this phenomenon actually
takes place when we expofe to the air compounds of
the fulphureous acid with different bafes, thefe being at
length found to contain fulphuric acid. Thus the
combination of the fulphureous acid with potafh, known
under the name of *Stahl's fulphureous falt*, or fulphite
of potafh, if expofed to the air, becomes at the end of
a certain time genuine fulphate of potafh. What, in
thefe inftances, is flowly effected, takes place with
more rapidity in the combuftion of fulphur ; during
which that combuftible body abforbs the oxigene of
the atmofphere, and becomes gradually more and more
acid, till it be completely faturated. (See the *Hiftory
of Sulphur.)*

From thefe facts it appears, 1. That the fulphuric
ácid is a compound of fulphur and oxigene. 2. That
when a combuftible body having a greater affinity than
fulphur with oxigene or the bafe of vital air, is mixed
                                             with

with it, that body decompofes the acid, by abforbing the oxigene. 3. That when the combuftible matter does not carry off all the acidifying principle, as happens in moft of the folutions of metals effected by the fulphuric acid, what is feparated is not pure fulphur, but fulphureous acid gas. 4. That this gas is a kind of intermediate body between fulphur and the fulphuric a-cid; and is to be confidered as differing from the acid, only by containing a fmaller proportion of oxigene; from fulphur, only by containing fo much oxigene as renders it faintly acid. To caufe it to pafs into the ftate of real fulphur, all that we need to do is, to drive off that portion of the bafe of vital air which it contains; as happens towards the end of the procefs in which metals are diffolved by the fulphuric acid, when thefe folutions are ftrongly heated and made to evaporate. We now like-wife underftand how the fulphureous is gradually con-verted into the fulphuric acid, by abforbing the oxigene of vital air contained in the atmofphere.

The fulphureous acid gas is capable of uniting in a very intimate manner with the fulphuric acid, and it then communicates to this acid the property of exhaling in thick white vapours. Meyer, in his Chemical Effays, on the article of Quick lime, mentions a *fuming oil of vi-triol*, prepared at Northaaufen in Saxony, from a diftil-lation of *common vitriol*. He likewife follows Chriftian Bernhard, a German chemift, in mentioning a concrete fuming acid falt obtained from this acid by diftillation. Finding an opportunity of procuring in Paris a confide-rable quantity of this fulphuric acid of Saxony, I obferved it to poffefs the properties afcribed to it by Meyer, and obtained from it, by ufing a gentle heat,

3   cryftallized,

cryftallized, concrete, volatile falt,'fuming and deliquef-
cent, under two different forms, according to Chriftian
Bernhard's account of it. 1 am convinced, from various
experiments related in a memoir of mine, read in the
Royal Academy of Sciences in the year 1785. 1. That
the property poffeffed by this black fulphuric acid of
Northaaufen, of fuming and affording a concrete vola-
tile falt, depends on its containing a great quantity of
fulphureous gas. 2. That in proportion as it lofes this
gas by being expofed to the air, it ceafes to exhale va-
pours, and lofes its power of affording concrete falt.
3. That water difengages this gas, and deprives the ful-
phuric acid of Saxony of its property of fuming, &c.
4. Laftly, That the fuming concrete acid falt obtained
from this acid by diftillation is a faturated combination
of fulphuric acid with fulphureous gas, which when ex-
pofed to the air, gradually paffes into the ftate of com-
mon fulphuric acid. We are therefore acquainted with
two concrete fulphuric acids, one of which owes its con-
cretion to nitrous gas, the other to fulphureous acid gas.
I make no doubt but the number of concrete acids may
be one day increafed, by fome other modifications of
of the fulphuric acid reduced to folidity by other gafes;
fuch as oxigenated muriatic gas, &c.

The fulphuric acid is made ufe of in many of the
arts, more efpecially by the dyer and the hat-maker,
&c. It is one of the moft common and ufeful men-
ftruums in the laboratory. In medicine it is externally
applied as a very ufeful cauftic, and internally as a re-
frefhing, cooling, and antifeptic medicine; but in this
cafe, it muft be diluted in water till it have fcarce any
fenfible acidity.

The fulphureous acid is ufed in dyeing, for whitening filks, taking out ftains, &c.

As thefe two acids are combinations of fulphur and oxigene in different proportions, their names ought to be analogous to their nature: to us they appear to be beft diftinguifhed by the names of the *fulphuric acid*, and the *fulphureous acid*. The termination of the word *fulphureous*, ferves in this, as well as in other inftances, to fhow that the acid to which it belongs contains an excefs of the combuftible bafe *.

<p style="text-align:center">Species VI. <i>The Boracic Acid.</i></p>

EXPERIMENTS made by a great many chemifts have fhown borax to be a neutral falt formed by the combination of foda with a peculiar acid: this acid was called by Homberg, its difcoverer, *fedative falt*. It has been fince named the *acid of borax*, and the *boracine acid*; we choofe rather to call it the *boracic acid*, in order that its name may terminate in the fame way as the names of the other acids.

Many chemifts have thought this acid to be merely a product of art formed by the combination of the falts ufed in obtaining it with fome principle of borax: But fince M. Hoefer, apothecary to the Grand Duke of Tufcany, has difcovered that the waters of feveral lakes in that country, for inftance, thofe of Caftelnuovo and Monterotondo, maintain in folution a confiderable quantity of

very

* The fulphuric acid is found, difengaged, in nature, in fome parts of Italy. Baldaffari has obferved it, in this ftate, in a grotto in Tufcany, at St. Albino, and at the lakes of Travale. Vandelli relates that fulphuric acid is fometimes found diffolved in water, in the environs of Sienna and Viterbo. M. Dolomieu found it in pure cryftals in a grotto on Mount Etna.—H.

very pure boracic acid; we can no longer entertain a doubt of its being a peculiar acid. The chemists of the academy of Dijon have confirmed this difcovery; on examining a quantity of water from the lake Montero-tondo fent them out of Tufcany, they found it to con-tain the falt which M. Hoefer had afcribed to it. It is very likely that the fame falt may be found in other mineral waters : it appears, as we fhall hereafter men-tion, to be formed by the putrefaction of fat bodies.

The boracic acid, whether native or obtained from borax, by proceffes which we fhall have occafion to de-fcribe under the article of that neutral falt, is a con-crete matter, cryftallized in fmall white fcales, very thin, irregularly formed, figured round their edges, extremely light, and fometimes glittering. It has a weak, yet a fenfibly acid tafte. It communicates a faint red to tincture of violets; but has a much ftronger effect on that of turnfol, mallows, raddifhes, &c.

When expofed to heat, it is not volatilized; but it melts when made red hot into a tranfparent glafs; and the glafs becomes opaque, and is covered with a light white duft when expofed to the air. This glafs is the boracic acid unaltered; it regains its lamellated form when diffolved in water, and caufed to cryftallize.

The boracic acid fuffers no fenfible alteration from the action of the air, whether it be dry, or moift, hot or cold.

It diffolves in water, not without difficulty; for, ac-cording to the academicians of Dijon, a pound of boil-ing water diffolves no more than 183 grains of this a-cid ; when cooled and partly evaporated, it returns to its cryftalline form. This folution inftantaneoufly red-

dens the tincture of turnfol, and alters, though more
flowly indeed, the colour of fyrup of violets. When a
quantity of the boracic acid, moiftened with a little
water, is heated in a cucurbite, fitted with a capital,
part of the acid is fublimated together with the va-
pour arifing from the water; but as foon as the whole
of the water is volatilized and the boracic acid left
dry, the fublimation ceafes: from which it appears
that the acid is of itfelf fixed, as may be fhown by
melting it in a crucible. By fublimating it in this man-
ner with water, if the procefs be fkilfully conducted,
it is obtained under a beautiful fparkling cryftalline
form. The boracic acid, after paffing through this pro-
cefs, is very pure, and is known in pharmacy by the
name of *fublimated fedative falt.*

ˈThe boracic acid ferves as a flux to filiceous earth ;
and the glafs which they form together is white or
faintly coloured. With the help of heat, it diffolves
the earth precipitated from the liquor of flints. It u-
nites with barytes, magnefia, lime, and alkalis ; and
forms by its union with thefe fubftances a clafs of pe-
culiar falts, diftinguifhed by the general name of *bo-
rates*, of which we are well acquainted with none but
one fpecies.

The whole of thefe properties, but more efpecially
its tafte, and the red colour which it communicates
to blue vegetable tinctures, fufficiently diftinguifh it
as an acid. But it faturates alkaline bafes only in
part; and is known to be the weakeft of all acids, as
all of the others, not even the carbonic acid excepted,
difengage it from the fubftances with which it com-
bines.

The

The action of the other acids on the boracic is not
well known. It appears to effect a partial decompo-
fition of the fulphuric acid ; for when diftilled on this
falt, the fulphuric paffes into the ftate of fulphu-
reous acid. As to the nitric and the muriatic acids
we know that they diffolve it ; but the phenomena
which take place on that occafion have not yet
been fufficiently attended to, to enable us to deter-
mine whether or not a mutual decompofition then takes
place.

A diverfity of opinions prevails concerning the na-
ture and the formation of the boracic acid. A num-
ber of chemifts have believed it to be an intimate com-
bination of the fulphuric acid, and vitrifiable earth
with a fat matter. Meffrs Bourdelin and Cadet think
it to be formed by the muriatic acid. The latter of
thefe two gentlemen thinks that it muft contain a fmall
quantity of earth of copper, becaufe it has the fame
property with the oxides of copper, of communicat-
ing a green colour to the flame of combuftible bodies.
Cartheufer affures us, that on drying and calcining by
the action of a flow fire, a quantity of the boracic acid
in a ftate of great purity, he obferved it to emit vapours
of the muriatic acid ; and that on diffolving this falt
thus dried, and filtrating the folution, he found a
grey earth remaining after the filtration; and laftly, that
by many repetitions of this calcination and folution, he at
length accomplifhed the entire decompofition of the bora-
cic acid, and found it to be a modification of the mu-
riatic acid fixed by an earth. This experiment has
been repeated by Meffrs Macquer and Poulletier de la
Salle ; they obferved an odorous vapour to be difengag-
ed

ed during the calcination of this falt, but they were not able to diftinguifh from its fmell that it was muriatic acid. By repeated deficcations and folutions, they obtained a fmall portion of grey earth; but the earth, when united with the muriatic acid, did not form fedative falt, as Cartheufer had given out; and of confequence this chemift's opinion appears to be no better fupported than the reft. Model thought this falt to be a combination of a peculiar alkali with the fulphuric acid, which is ufed in difengaging it. But this opinion cannot be admitted; for the boracic acid is always the fame, whatever be the acid ufed to precipitate it. M. Baumé fays, that he found means to produce the boracic acid by leaving a mixture of greafe and clay to macerate for 18 months. At the end of that time, he obtained from it, by lixiviation, a falt in fmall fcales, with all the properties of *fedative falt.* From this he concludes the boracic acid to be a combination of the acid of greafe with a very fine earth, which it is impoffible to feparate entirely from it. He adds, that the fame falt may be produced with vegetable oils, but more flowly. M. Wiegleb repeated M. Baumé's experiment, but without obtaining boracic acid.

Chemifts at prefent think this to be a peculiar acid differing from all others, and poffeffing certain characteriftics of its own. Its elective attractions for alkaline bafes are arranged by Bergman in the following order; lime, barytes, magnefia, potafh, foda, ammoniac. As they differ greatly from thofe of the other acids above-examined, they afford an additional proof

of

of the peculiarity of the nature of this acid, whofe component principles remain ftill unknown.

The ufe of the boracic acid in medicine, was firft introduced by Homberg, who afcribed to it quieting narcotic qualities, and gave it the name of *fedative falt*, or *volatile narcotic falt of vitriol*, becaufe he had obtained it by fublimating a mixture of *nitre* and *vitriol*, But experience has fince fhown the medical virtues of this falt to be but very moderate ; at leaft it muft be given in a much ftronger dofe than Homberg has directed, in order to produce the effects he afcribes to it ; and it is very properly rejected, as we have many other medicines of the fame clafs, whofe effects are much more certain.

It is ufed in many operations of chemiftry, and in the affaying metals as a flux. We will fpeak of its application to this purpofe in a fubfequent chapter*.

C H A P.

* The water of the lake Cherchiajo, near Monterotondo, in the Lower Siennefe, afforded to M. Hoefer, three ounces of pure acid of borax, out of an hundred and twenty pounds of the water : 12,280 grains of the water of the Lake of Caftelnuovo, afforded 120 grains of pure boracic acid. Some pure boracic acid was collected in the mines of Tufcany by M. Beffon. Mr Weftrumb found borax in the *cubic* quartz of Limeburg —H.

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C H A P. V.

UNDER the name of *fecondary falts*, are compre-
hended all fuch fubftances as are formed by the
combination of two primary faline matters. They
have received the name of *neutral falts*, becaufe they
poffefs not the charaΔeriftics of primary falts; that is,
they are neither acid nor alkaline. Yet feveral of them,
fuch as borax, chalk, and alkalis when united with
the carbonic acid, exhibit, though in an inferior de-
gree, fome of the properties of primary falts. Thefe fe-
condary falts have not fo ftrong a tafte as moft of the
primary; nor do they diffolve, or enter into new com-
binations fo readily. But, what principally diftin-
guifhes them from the primary is, their inability to
communicate faline properties to other bodies. Their
cryftalline form is another charaΔeriftic by which
they are diftinguifhed; it merits the attention of the

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naturalift; but, though it fometimes determines their nature, it alfo occafions frequent miftakes.

The term *bafe*, is commonly ufed to denote the more fixed part of the compofition of neutral falts. As this bafis, which is fometimes volatile, communicates feveral pretty uniform general characteriftics to the various combinations with acids, of which it admits, we fhall ufe the name of the *bafe*, to diftinguifh the genera of fecondary falts. Thefe falts may then be divided into fo many genera as there are faline or alkaline bafes capable of being united with acids.

The firft genus comprehends all fuch as are formed by the union of the two fixed alkalis with any of the acids. Thefe we fhall denominate *perfect neutral falts;* becaufe the union of their component parts is very intimate:

The fecond genus includes thofe falts which are formed by the combination of volatile alkali, or ammoniac with acids. They have received the name of *ammoniacal falts* from the modern name of their bafe. They may alfo be called *imperfect falts*, becaufe they are much eafier decompofed than thofe of the former genus.

In the third genus are ranked fuch as have lime for their bafe. Thefe are in general more imperfect than thofe of the fecond genus, although lime has a ftronger affinity than ammoniac with the acids, as will be afterwards particularly fhown. They are denominated *calcareous neutral falts.*

The fourth genus confifts of combinations of magnefia with various acids. Thefe falts are ftill more eafily

fily decompofed than thofe of the laft mentioned ge-
nus ; becaufe acids have a ftronger affinity with lime
and alkalis than with magnefia.   Their proper name is
magnefian neutral falts, or neutral falts with a bafe of
magnefia.

To the fifth genus belong thofe of which the bafe
is pure argillaceous or aluminous earth.   Alum being
the chief of thefe combinations, they have received the
generic name of *aluminous falts*.   Aluminous neutral
falts are almoft always decompofed by the operation of
alkalis, lime, and magnefia.

Laftly, To the fixth genus we affign neutral falts,
having a bafe of barytes or ponderous earth. Both thefe
and the greater part of the two preceding genera are
but very little known.   *Barytic falts* is the diftinctive
name of this genus.

It may be eafily imagined, that thefe feveral ba-
fes, when combined with the acids whofe properties
we have examined, muft afford a very confiderable
number of neutral falts : and this number will be much
more confiderable, if, with Bergman, we admit as di-
ftinct falts the various combinations of thefe fame
bafes with thofe acids which he calls *phlogifticated;* and
which, according to the modern doctrine, are deprived
of a part of their pure air or oxigene.   But as thefe
compounds are liable to alterations on coming into con-
tact with air, which caufes them almoft inftantly to af-
fume the character of real neutral falts, it feems impro-
per to add them to a lift which is already but too nume-
rous ; we fhall, however, point out what peculiar pro-
perties they acquire from the ftate of their acids.   We

C c 2   muft

muft obferve farther, that although the alkaline bafes here enumerated, when combined with aqua regia, afford a mixture of nitrous and marine falts, yet as thefe may be obtained feparate, and are perfectly the fame with thofe produced by the fimple acids ; we mean, therefore, to take notice of them only when fpeaking of the combination of alkaline bafes with the fimple acids. Having hitherto examined no more than fix principal acids, we are to treat only of the neutral faline combinations into which thefe enter.

In the arrangement of the feveral fpecies of the neutral falts, the moft natural order feems to be that of the affinities of the acids: and, therefore, through all the genera, we begin with fulphatic falts, proceeding from them to the nitric ; after which we treat fuccesfively of thofe whofe bafes are combined with the marine, the boracic, the fluoric, and the carbonic acids, the laft of which is the weakeft of all.

That our nomenclature may be clearly expreffive of the nature of the fubftances to which it refers, the name which we affix to each of thefe falts is compounded of the name of its acid and that of its bafe; and the various names by which any neutral falt has been known at different periods are carefully fubjoined.

Genus

Genus I. *Perfect Neutral Salts*, or *Salts with a base of fixed Alkali.*

Species I. *Sulphate of Potash.*

SULPHATE of potash, which has been alfo called *vitriolated tartar*, *Sal de duobus*, *Polychreft falt*, and *Arcanum duplicatum*, is a perfect neutral falt, refulting, as its new name denotes, from the combination of the fulphuric acid with potafh. It feldom appears in the mineral kingdom; but a few vegetables contain a fmall quantity of it.

This falt is generally in a greater or a lefs degree tranfparent and regular; its cryftals differ in form and magnitude, according to the circumftances in which they are obtained. When formed flowly in the fmall way, they affume the figure of tranfparent fix-fided pyramids, nearly fimilar to rofe-diamonds; and fometimes, though lefs frequently, they take the form of fix-fided prifms, terminating in two hexahedral pyramids, much like rock cryftal. But if the evaporation be very rapid, the cryftals are agglutinated into one mafs, under the form of a folid cruft, the furface of which is covered with fmall irregular pyramidal fpikes: of this kind is the falt of this name met with in commerce. Laftly, when, in order to obtain the cryftals as regular as pof- fible, a folution of this falt is expofed to a gentle fpontaneous evaporation by the heat of the atmofphere, its cryftals are generally folid twelve fided figures, joining at the bafe, and fometimes feparated by a fhort fix-fided prifm. Thefe indeed are ufually foul, and at no time

C c 3   equal

equal the whitenefs and tranfparency of thofe which are
obtained by the former procefs of evaporation. But
one imperfection attending moft of thefe neutral falts
is, that they are either of a dark colour or an irregular
figure.

Sulphate of potafh has a very difagreeable bitter
tafte.   Fire produces but little alteration upon it.
When laid on burning coals, it breaks with noife into
a number of little pieces : This phenomenon, which is
called *decrepitation*, arifes from the fudden rarefaction
of the water which entered into it when it was cryftal-
lifed.   But fulphate of potafh lofes none of its effential
properties by decrepitation.   It decrepitates in the fame
manner when expofed to the action of fire in a cru-
cible, and becomes dry, friable, and even pulverulent,
by lofing the water which it contained : it becomes red
before melting, and a ftrong fire is requifite to bring it
to fufion.   If expofed to cold when in a ftate of fu-
fion, it becomes an opaque mafs, friable, and foluble :
it appears likewife to have fuffered no alteration of its
principles ; for it regains its tranfparent and cryftalline
form on being diffolved in water.   If kept for a while
in the ftate of fufion in an open veffel, it is volatilifed,
but without being decompofed.

Sulphate of potafh fuffers no alteration from air.   It
remains in its cryftalline ftate, without fuffering any
change either of form or of tranfparency.   It is fcarce
foluble in water ; yet the difficulty of diffolving it is
greater or lefs according to the temperature of the
fluid.   According to Spielman, about 18 parts of cold
water are required to diffolve 1 of this falt.   But boil-
ing water diffolves it nearly in the proportion of 4 to 1 ;

                                                      for

for M. Baumé affures us, that 4 ounces of boiling water diffolve 7 drams and 48 grains of fulphate of potafh. It is cryftallifed partly by cooling, but ftill more by evaporation : It contains but very little water in its cryftals, and therefore fuffers no change of ftate when expofed to the air.

Sulphate of potafh acts not at all on the fimple earths. When accidentally mixed with falts ufed as fluxes in making glafs, it is found again in the fcoriæ; and it is obtained in confiderable quantities from glafs gall.

According to Bergman, barytes or ponderous earth having more affinity than potafh with the fulphuric a- cid, decompofes this neutral falt. If a folution of this earth be poured on a folution of fulphate of potafh, this procefs forms a precipitate of barytic fulphate or *ponderous fpar*, which is abfolutely infoluble; its pro- perties we fhall hereafter examine. The potafh, if pure and cauftic, remains diffolved in the liquor.

Lime and magnefia act not on fulphate of potafh; but many of the acids act very forcibly upon it. Rouelle difcovered that it is poffible to combine with this falt a greater quantity of the fulphuric acid than it naturally contains. His procefs confifts in diftilling a quan- tity of concentrated fulphuric acid on fulphate of potafh. The neutral falt becomes impregnated with the acid, and acquires new properties : it now reddens the tincture of violets, is foluble in water, has a four tafte, and effervefces with alkalis faturated with car- bonic acid, even after being diffolved and cryftallifed. M. Baumé has maintained, that no real combination takes place between the acid and the neutral falt, and that they may be feparated merely by placing them on

bibulous

bibulous paper or fand. But Macquer remarks, that
the fulphuric acid adheres with no inconfiderable force
to fulphate of potafh ; and thinks that their mutual ad-
hefion muft be owing to a peculiar affinity between the
two fubftances: according to him neither fire nor water
is able to feparate them. I have feveral times combin-
ed the concentrated fulphuric acid with fulphate of pot-
afh, in Rouelle's way ; that is, by diftillation in glafs
retorts, and have obferved fome phenomena not men-
tioned in his differtation on the fubject. Sulphate of
potafh melts on the occafion into a kind of glafs or opaque
white enamel of a ftrong acid tafte : but this vitreous frit
does not attract moifture from the air ; on the contrary,
it rather exhibits appearances of efflorefcence, when the
acid makes only a fourth part of the total weight.
There is, therefore, as Macquer thought, a pretty ftrong
adhefion between the neutral falt and the acid ; and that
adhefion is no doubt owing to a peculiar combination.

M. Baumé has obferved, that fulphate of potafh fuf-
fers a very confiderable alteration from the nitrous
acid. If aquafortis be boiled on this falt, the nitrous
acid feizes on part of the potafh, and difengages the
fulphuric acid contained in it. When this mixture is
fuffered to cool, its cryftals are pure nitre. It was at
firft thought that this decompofition could not take
place without the help of heat; but if fuming fpirit
of nitre be poured on fulphate of potafh in powder, it
will be found at the end of fome hours to have depo-
fited cryftals of nitre. It was likewife advanced, that
when the mixture became cold, the fulphuric acid, re-
fuming its rights, decompofed in its turn the nitre of
potafh : but I have kept mixtures of fulphate of potafh
                                                    with

with fpirit of nitre for feveral years, and at the bot-
tom of the mixture there were always faline cryftals
which detonized on burning coals, and fuffered no
change of nature though immerfed in the fulphuric
acid feparated by the nitrous. M. Cornette has ob-
ferved, that the concentrated muriatic acid likewife
decompofes fulphate of potafh, even cold. From thefe
two facts it would appear, that the law of affinity re-
fpecting thefe different acids does not hold fo invariably
as was imagined. Yet we muft obferve, with Bergman,
1. That whatever quantity of the nitrous and muriatic
acids be made ufe of in thefe experiments, no more than
a third part of the given quantity of fulphate of potafh
·is ever decompofed ; while the fulphuric acid, when ap-
plied in a moderate proportion to nitrous and muriatic
falts, effects a total decompofition of them : 2. That fuch
a decompofition never takes place, except when the ful-
phate of potafh contains rather more of the fulphuric a-
cid than is neceffary to conftitute it a neutral falt. 3.
That the affinity of fulphate of potafh for the fulphuric
acid, is the true caufe of thefe decompofitions, and that
undecompofed fulphate of potafh, is very acid.

But of all the modes of decompofition to which ful-
phate of potafh is liable, the moft worthy of our atten-
tion is that which it fuffers from many combuftible mat-
ters, more efpecially from charcoal and feveral metallic
fubftances (See my *Memoires de Chimie,* p. 225.). If a
mixture of this falt with coal be ftrongly heated in a cru-
cible, the fulphate of potafh will be converted in·o ful-
phur united with the fixed alkali. Stahl thought this a
very happy experiment for demonftrating the exiftence
of phlogifton; modern chemifts explain it by the pneu-

matic theory. In the hiftory of fulphur, we fhall give both theories.

A quintal of fulphate of potafh in cryftals contains, according to Bergman, about 52 parts of potafh, 40 of fulphuric acid, and 8 of water,—which laft is neceffary to make it cryftallize.

As this falt is found but feldom in nature, and even then in fmall quantities, the fulphate of potafh made ufe of in medicine is always a product of art. There are three ways of preparing it. Firft, by a direct combination of the fulphuric acid with potafh. This inftantly produces fulphate of potafh, which may be diffolved in water, and cryftallized, as we have mentioned above. The fecond way is, decompofing, by means of the fulphuric acid, neutral falts confifting of potafh united with other acids; fuch as nitrate, muriate, and carbonate of potafh, &c.: Sulphate of potafh is infallibly obtained by all of thefe decompofitions. The third way of forming this falt is by ufing potafh to decompofe earthy and metallic fulphuric falts. The potafh precipitates the falino-terrene fubftances and the metallic oxides, and feizes the fulphuric acid. We will have occafion to take farther notice of the laft two of thefe methods of preparing fulphate of potafh, when we come to give an account of the neutral falts ufed in the preparation *.

This falt is not much ufed except in medicine. It is a pretty efficacious purgative. It is fometimes given by itfelf in dozes of half an ounce or an ounce.

But

* Mr. Chaptal relates, that he had occafionally obtained fulphate of potafh from the analyfis of tobacco.—H.

But it is moſt generally given, a dram or two at once, together with ſome other purgative medicines. It is uſed as a ſolvent in chronical diſtempers, particularly in coagulations of milk. It is then given in doſes of a few drams together in certain preparations of liquids; but its ſolvent power is much inferior to that of many other neutral ſalts, which are more ſoluble and leſs nauſeous.

The ſulphureous acid, or the ſulphuric with an o-verplus of ſulphur, forms, when combined with potaſh, a ſalt ſomewhat different from that which we have been conſidering. Stahl called it *ſulphureous ſalt ;* we give it the name of *ſulphite of potaſh.* This ſalt cryſtallizes in polyhædrons of ten ſides, or in two te-trahædral pyramids cut towards their baſes: it is very bitter, eaſily ſoluble, and rather deliqueſcent. Almoſt all mineral acids, and many vegetable acids, diſengage the ſulphureous acid from this ſalt with efferveſcence, and in a gaſeous form. Sulphite of potaſh, when ex-poſed to the air, gradually abſorbs oxigene, and is con-verted into ſulphate of potaſh *.

Species II. *Sulphate of Soda.*

Sulphate of ſoda, which has been hitherto known by the name of *Glauber ſalt,* from the name of the Ger-man chemiſt who firſt diſcovered it, is a perfect neu-tral ſalt, formed, as its name indicates, by the union of the

* In oppoſition to facts above related by M. Fourcroy, M. Chaptal aſſerts, that in 1780, he himſelf ſhewed that the *nitric* acid, without aſſiſtance, will diſſolve ſulphate of potaſh; but that the ſulphuric acid reſumes its place, when the ſolution is concentrated by heat.—H.

the fulphuric acid with mineral alkali or foda. This falt poffeffes many properties in common with fulphate of potafh, and fome peculiar to itfelf. It is equally difpofed to cryftallize as the other; has a bitter tafte; is fcarce fufible; diffolves in water; is incapable of union with earths; and, like fulphate of potafh, is decompofable in part by the nitrous and muriatic acids. Many of its properties, however, are confiderably different from thofe of fulphate of potafh; as we fhall fee by examining them particularly.

Sulphate of foda is commonly a body of a regular form, and more or lefs white or tranfparent. Its cryftals are prifms with fix unequal and ftriated fides terminating in dihædral fummits. They are feldom under a regular form, and the number of the fides varies as well as their fize, pofture, and ftriæ; as M. Romé de Lille has fhown very particularly in his cryftallography. The prifms of this falt vary in fize from the form of fmall needles, very minu.e, to prifms half an inch in diameter and fix or eight in length; which laft are obtained when a great quantity is cryftallized at once. Its tafte is at firft frefh, but foon becomes very difagreeably bitter. It produces no alteration on blue vegetable colours.

When expofed to the action of fire, it is quickly liquefied: but it foon dries and becomes of an opaque white colour; in which ftate it is no lefs difficult to melt than fulphate of potafh. In order to form a juft notion of what paffes when heat acts with this effect on fulphate of foda, we mult take notice that faline fubftances are melted two ways. 1. By means of the water which enters into their cryftals, which is called

aqueous

aqueous fusion. This takes place only on such salts
as are more foluble in warm than in cold water ; which
happens becaufe the portion of the fluid which enters
into conftitution of their cryftals, being then warm-
ed, diffolves the faline matter. This aqueous fufion is
therefore nothing more than folution by warm water :
and therefore fulphate of foda affumes again a folid
form when it is fuffered to cool. 2. But if the heat be
continued after it is liquified, it becomes dry and white:
it may then be melted by means of a more intenfe heat ;
and this fufion is actually the effect of fire, and there-
fore called *igneous fufion.* Sulphate of foda is there-
fore no lefs difficult of fufion than fulphate of potafh ; ·
and like it is volatilized by the extreme violence of
fire, but fuffers no alteration of principles from the ac-
tion of heat.

It is likewife on account of their containing a great
quantity of water, that the cryftals of fulphate of foda
when expofed to the air, are in a fhort time reduced
to a very fine white powder. This phenomenon is
called *efflorefcence ;* becaufe in fact the cryftals are co-
vered over with a kind of fine flour, in whitenefs and,
form refembling the fublimated matters which are
known in chemiftry under the improper name of *flowers.*
The caufe of this falt's falling down in this manner,
when expofed for fome time to the air, is its lofing the
water on which the conftitution of its cryftals depends.
It therefore efflorefces moft readily when the air is ve-
ry dry, and of confequence eager to abforb moifture.
This phenomenon, therefore, bears a great refemblance
to the deficcation effected by heat : both depend on
the evaporation of the water to which the cryftalline

3 form

form is owing. Yet, as the water which enters into
the cryftals of fulphate of foda, and of all efflorefcent
falts in general, is perfectly combined with the faline
matter ; efflorefcence appears to be owing to a kind of
elective attraction between air and water. This phe-
nomenon is therefore to be confidered as a decompofi-
tion of cryftals, taking place in confequence of water's
having a greater affinity with air than with the faline
matter. Such has always been my idea of effloref-
cence, and I do not fee how it can be explained other-
wife, (See my *Memoires de Chimie*). Sulphate of fo-
da lofes almoft half its weight when it undergoes this al-
teration : but its nature is not changed, and we may
caufe it to refume its cryftalline form, by reftoring to
it the water which it has loft. Though no writer on the
Materia Medica have as yet made the obfervation, yet
to me, it feems an object of fome importance, to know
the exact quantity of water which fulphate of foda lofes
when it efflorefces, in order that the fame quantity may
be always prefcribed for a dofe, in whatever of the two
ftates the falt may happen to be. Rather more than
one-third lefs of this falt fhould be given when it is in a
ftate of efflorefcence than when it is under the form of
fine tranfparent cryftals.

Sulphate of foda diffolves very eafily in water. No
more than four parts of cold water are neceffary to dif-
folve one of this falt. But a fmaller quantity of warm
water will be fufficient to diffolve the falt, and a ftill
fmaller quantity in proportion as the water is made
hotter. One part of boiling water diffolves almoft as
much of this falt as is equal to its own weight. The
method in which we make it cryftallife is founded on
this

this property. As it is more foluble in warm than in cold water, all that we need to do is, to leave a ftrong folution of this falt to cool ; and it affords cryftals which are more or lefs regular, and of a greater or a fmaller fize, in proportion as the quantity of the folution is greater or lefs, and as it is cooled more flowly or more quickly. In the laboratories of apothecaries, where this operation is performed in the great way, ftriated prifms feveral inches long are often obtained, which afford fpecimens of the regularity of the form of this falt.

Sulphate of foda acts no more on filice or alumine than fulphate of potafh : and as it is fo difficult of fufion, it is no more ufed in making glafs than the other. Barytes decompofes it as well as fulphate of potafh ; but the other falino-terrene fubftances produce no alteration upon it.

Pure cauftic potafh, mixed with a folution of fulphate of foda, decompofes it ; becaufe it has a ftronger affinity than foda with the fulphuric acid. In order to receive full conviction of this, the reader may pour a lixiviate of cauftic potafh on a warm and ftrongly futurated folution of fulphate of foda. This folution, which, if fuffered to cool, would have afforded cryftals of the latter, gives fulphate of potafh by evaporation ; and the mother water contains cauftic foda.

The fulphuric acid combines with fulphate of foda, and adheres to it in the fame manner as to fulphate of potafh.

- The nitric and the muriatic acids decompofe it with the fame attendant circumftances as when they decompofe fulphate of potafh.

3   When

When fulphate of foda is violently heated with char-
coal and fome metals, the fulphuric acid affumes the
form of fulphur, as we fhall have occafion to mention
under the hiftory of that combuftible body.

All the properties in which fulphate of foda differs
from fulphate of potafh, ferve as fo many proofs that
the two fixed alkalis, however fimilar in their ftate of
purity, are neverthelefs extremely different from each
other; becaufe they form very diffimilar falts when
combined with the fame acid. Befides, the proportion
in which the principles of this falt are united, is very dif-
ferent from that by which fulphate of potafh is formed:
for, according to Bergman, a quintal of fulphate of fo-
da contains 15 parts of foda, 27 of fulphuric acid, and
58 of water *.

This falt is more copious in nature than fulphate of
potafh. It is obtained in great abundance from fea-
water, from the water of certain falt fprings, and more
efpecially from many mineral waters. Art can likewife
procure it by the three methods of which we have giv-
en a defcription in the hiftory of fulphate of potafh. It
is not more ufed in the arts than that falt ; but much
more in medicine. It is given as a folvent, aperient,
and purgative, in dofes of—from half a dram to an
ounce and an half, according to the cafes in which it
is adminiftered. Its effects are even more ftrong and
quick than thofe of fulphate of potafh ; becaufe its fa-
pidity is greater, and it diffolves much more readily in
the humours of the human body †.

We

* Others affert, that 100 grains of fulphate of foda contain 14 a-
cid, 22 alkali, and 64 water.—H.

† The *tamarix gallica*, a plant growing on the fea coaft of France,
contains fulphate of foda in a large proportion.—H.

We are ignorant of the properties of fulphite of foda, or of that falt which is formed by the combination of the fulphureous acid with alkali of foda.

Species III. *Nitrate of Potafh, or Common Nitre.*

NITRATE of potafh, common nitre, or faltpetre, is formed by a faturated combination of the nitric acid with potafh. This falt has a frefh tafte, is a perfect neutral falt, and does not alter the colour of fyrup of violets. Its cryftals are fix-fided prifms, terminating in dihedral pyramids, or cut off with a flope, and often channelled from one end to the other.

There is great abundance of this falt in nature : it is continually forming in places inhabited by animals. It is likewife found in abundance on walls fheltered from rain ; and is then called *faltpetre de houffage.*

There feem to be three circumftances which chiefly promote its formation. The firft of thefe is the prefence of chalk, or fome calcareous fubftance ; in this manner is the nitre formed which is gathered on walls covered with plafter; and from this circumftance, confiderable quantities of nitre are ufually found on the demolition of old buildings. This falt is obtained in a ftate of perfect purity from chalky earths. The Duke de la Rochefoucault has obtained it in the proportion of an ounce to the pound from chalk of Roche-Guyon.

The fecond circumftance favourable to the production of faltpetre is the putrefaction or fpontaneous decompofition of animal and vegetable matters. It is a well known fact, that places watered with animal liquors, or containing animal matters in a ftate of putre-

faction, fuch as dunghills, ftables, jakes, afford great quantities of nitrate of potafh. This fact has always been gone upon as a principle, in forming beds for the artificial production of nitre. Ditches or covered fheds are formed, and left expofed on all fides to the air: thefe are then filled with putrefcent fubftances, fuch as dung of all kinds, and vegetable fubftances; water containing animal or vegetable matters is from time to time poured on the mafs ; and it is ftirred now and then to change the relative difpofition of the furfaces. When the putrefaction is confiderably advanced, a fmall portion of the matter is taken and lixivated, in order that it may be known whether it contains nitre; and if it be found to contain a fufficient quantity of the falt, the whole mafs is fubjected to the fame procefs.

The third circumftance apparently favourable to the production of nitre, is the contact of the air. This is one great caufe of the formation of the faltpetre found on walls ; and it is on this principle that the mixture depofited for the artificial production of nitre is frequently ftirred, in order that the air may have accefs to every part of the mafs. Beds of chalk, which naturally contain nitre, afford it only to a certain depth, and not lower. Where thefe three circumftances meet, nitre is produced in great abundance. Beds for the artificial production of nitre fhould be formed on thefe principles.

It is but a very fhort time fince the theory of the production of nitre came to be known. Glauber, and a number of chemifts who implicitly adopted his opinion, thought this falt to be entirely formed in vegetable fubftances, in them conveyed into the bodies of animals,

animals, and by putrefaction only difengaged into a
free feparate ftate : But it was foon obferved, that the
vegetables ufed for its production in nitre-works could
not be fufficient to afford, of themfelves, the quantities ob-
tained. M. Thouvenel, who by his effay on the formation
of nitre gained a prize from the Academy, made a great
many experiments with a view to difcover its caufe,
and found that the nitric acid was formed by the com-
bination of an elaftic fluid difengaged from animal mat-
ters in a ftate of putrefaction with vital air. He has
alfo fhown that this acid, when formed, combines with
calcareous earth, where nothing but animal matters is
ufed for nitre beds; and that the ufe of vegetable fub-
ftances is to furnifh fixed alkali or potafh, which is the
bafe of common nitre. M. Thouvenel had not deter-
mined the nature of the gas which is difengaged from
animal matters in a ftate of putrefaction. And Mr Ca-
vendifh has fince fhown it to be the fame with that
which, under the name of phlogifticated air, atmofphe-
ric mephitis, or gas azote, conftitutes one of the princi-
ples of the atmofphere. By combining this gas with vi-
tal air, by means of the electric fpark, he obtained a
product of genuine nitric acid.

Nitrate of potafh is very liable to alteration from heat.
When expofed to the action of fire in a crucible, it foon
liquefies—by igneous fufion ; for though kept for fome
time in that ftate, it does not become dry ; and though
made red hot, does not affume a pulverulent form.
When fuffered to cool, after being melted, it congeals
into an opaque mafs which is named *cryftal mineral*, and
is equally ponderous, fufible and foluble with nitrate of
potafh. The cryftal mineral of the apothecaries fhops

is fomewhat different from pure melted nitre : for it contains a little fulphate of potafh, produced by the com- buftion of fulphur, which, according to the Parifian pharmacopœia, is ufed in the proportion of a dram to the pound of nitre, in the preparation of it.

If nitrate of potafh be left expofed to the action of fire, after being melted, it will be of itfelf decompofed and reduced to alkali. This operation fucceeds equally well in a retort ; and when performed in this manner, is of ufe to explain the decompofition of the nitric acid. In fact, inftead of the nitric acid paffing off pure, there efcapes a large quantity of an aëriform fluid, which may be collected under water, and is found to be genuine vital air mixed with gas azote. The re- fidue of alkali ufually melts the retort very foon after it is feparated ; and when we wifh to purfue the ope- ration to a conclufion, we muft ufe a ftone retort which may be proof againft its action. Here we have the nitric acid entirely decompofed into vital air and gas azote by means of heat, which alone is able to feparate thefe two principles. If the heat be not continued fo long, or made fo intenfe, as to effect the entire decom- pofition of the nitrate of potafh. The alkali ftill retains a certain quantity of the nitrous acid, or of the nitric with an excefs of nitrous gas. This acid may be difengaged from it by vinegar. In this ftate, the falt is what we call *nitrite of potafh*, the nitrous acid being fuperfatu- rated with gas azote ; in the fame manner we called the combination of the fulphureous acid with potafh, *fulphite of potafh.* If nitrate of potafh be acted upon by a very intenfe heat, a refidue of pure cauftic alkali is obtained. Since heat decompofes nitrate of potafh

λ   with

with fuch facility, it may be naturally inferred, that
when cryftal mineral is prepared by fimple fufion, the
falt muft not be too long expofed to the fire. If this
precaution be neglected, the medicine will contain
more than a juft proportion of potafh, and will produce
too violent effects.

The decompofition of nitrate of potafh is attended
with other phenomena, when it is expofed to the ac-
tion of fire, together with combuftible bodies. When
laid on a coal it gives a white lively flame, attended
with a kind of decrepitation: this is called the *detona-*
tion, or fufion of nitre: the falt is then faid to deto-
nize or melt; and by this characteriftic, nitre may be
at any time eafily diftinguifhed. Stahl thought this
phenomenon to be owing to the rapid combination of
the acid of nitre with phlogifton; and M. Baumé pro-
ceeding on the fame theory, thought that in this ope-
ration a quantity of nitrous fulphur was formed, which
was inftantly inflamed. In the year 1780, I read in
the Academy a Memoir, in which I have fhown that
nitrate of potafh is neither combuftible of itfelf not
yet forms nitrous fulphur when it detonizes; and that
this phenomenon is entirely owing to the flower or
quicker combuftion of the combuftible matter necef-
fary to make the falt detonize, in confequence of the
difengagement of the vital air, which efcapes in great
abundance from nitrate of potafh ftrongly heated. This
theory is completely proved : 1. Becaufe the falt ne-
ver detonizes by itfelf. 2. Becaufe after its detonation
by means of an inflammable matter, this matter is
found to be entirely burnt up. 3. Becaufe the greater
the quantity of the nitrate of potafh in proportion to

that

that of the combuftible matter, the more complete is the combuftion of the latter fubftance. 4. Becaufe detonation takes place as well in clofe veffels as in the open air, which could not poffibly happen if the falt did not furnifh vital air. This affertion receives the fulleft fupport from the phenomena attending the procefs for making the *clyffus* of nitre ; which is merely a detonation of this falt with different combuftible matters in clofe veffels. We fhall mention here only that which is made with charcoal. Two or three large receivers fitted together are applied to a retort of earth or iron, with an orifice in the upper part, which may be clofed with a cover or ftopper. This veffel is heated till its bottom be made red, and then a mixture of nitrate of potafh with coal is put in by the orifice, which is immediately fhut. During the detonation, the receivers are filled with vapours, part of which is condenfed into an infipid liquor, not at all acid, but often alkaline. The refidue is potafh faturated with carbonic acid : the nitric acid is then totally decompofed, and a large quantity of gas is produced, which I have collected by fitting to the orifice in the upper part of the receivers, either a bladder or tubes, the extremities of which entered glaffes full of water. This gas was moftly carbonic acid mixed with a little inflammable gas and gas azote ; the laft of which is one of the principles of the nitric acid. The inflammable gas is produced in confeqüence of the decompofition of part of the water of nitre by the charcoal.

The refidue, after the detonation of nitrate of potafh with charcoal in a crucible, is improperly called

nitre

nitre fixed by charcoal: it is potash combined with carbonic acid.

Nitrate of potash, when very pure, suffers no alteration from the action of the air.

It is easily soluble ; for three or four parts of boiling water dissolve one of nitre, and boiling water dissolves a quantity of it equal to twice its own weight. It therefore crystallises very readily by cooling. On its possessing these two properties is founded the art of extracting nitrate of potash from plaster or rubbish containing it. The saltpetre-makers put the pounded plaster or rubbish into a vessel with a hole at the bottom, and cover it with ashes. Through this matter they pour water; taking care to pour pure water on rubbish that has been already washed, till it be deprived of all the nitrous matter it contains ; and pouring water already impregnated with nitre upon the unwashed rubbish, in order that it may be completely saturated. They next evaporate the lixivium thus formed in copper vessels. They skim off the first pellicles, which are only the muriate of soda or marine salt contained in the rubbish. This salt they called *grain ;* and by their regulations, they are obliged to carry it to the refining houses. When the water is evaporated to such a degree, that the residue when cool must become solid, they put it into other vessels in which the nitrate of potash is crystallized. This salt, which is very impure and dirty, is called *nitre of the first boiling.* Some chemists have been of opinion that the ashes used in making saltpetre served only to cleanse the nitrate of potash of certain greasy impurities; and that opinion appeared to be supported by the fact, that these matters con-

tain hardly any alkali, and the afhes of tarmarifk, ufed
by the falt-petre makers of Languedoc, contain only
fulphate of foda. But this falt, as well as fulphate of
potafh, is as ufeful as an alkali for decompofing the cal-
careous nitrate, which is found in fuch abundance in
plafter and rubbifh, by the way of double elective at-
traction, as M. Lavoifier has obferved with refpect to the
lixiviated afhes ufed by the faltpetre makers of Paris.
We fhall fay more upon this under the title of *Calcare-
ous Nitrate.*

Nitrate of potafh of the firft boiling is always very
impure. It contains five other kinds of falts befide
pure nitre ; namely, muriate of foda, nitrate of mag-
nefia, calcareous nitrate, muriate of magnefia, and cal-
careous muriate ; and thefe muft be feparated, if we
wifh to obtain nitrate of potafh in a ftate of purity.
The mixture is purified of thefe falts, by diffolving it
again in the fmalleft poffible quantity of water, and
clarifying this boiling liquor by means of bullock's
blood, which carries off all impurities by collecting
them on the furface in the form of a fcum. This lix-
ivium is then evaporated, and by cooling the refidue, a
nitrate of potafh is obtained, much purer than the for-
mer, which is faid to be *nitre of the fecond boiling.*
Still, however, it is vitiated by a certain quantity of
muriate of foda and mother-water. It is a third time
purified by the fame procefs, and it then becomes
much purer and whiter ; and is now *nitre of the third
boiling.* As it is made to cryftallife very rapidly, it is
obtained in large irregular maffes ; and yet in the
middle of the veffels there is formed a layer of long
regular cryftals, which is called *nitre in ficks.* Nitre
under

under this laft form is not ufed in arfenals, being not fo fit for making good gun-powder as nitre in large irregular maffes; becaufe the water which entered into it when it was cryftallized would retard the combuftion of the powder.

Chemifts and apothecaries go on to purify nitre of the third boiling by new folutions and cryftallizations. By this means they are certain of at length obtaining very pure nitrate of potafh, entirely free of every extraneous mixture, and containing no muriate with either foda, lime, or magnefia for its bafe: Though thefe are fcarce ever entirely taken away where the operation is performed in the great way *.

Nitrate of potafh appears to be liable to fome alteration from filiceous earth; for by diftilling it with fand the acid is feparated. This acid comes off colourlefs, but fome vapours are diffufed at the time. The refidue is vitreous in a greater or a lefs degree, according as there was a greater or a lefs quantity of fand employed, and as the heat was weaker or more intenfe. Sand appears to decompofe nitrate of potafh by its tendency to combine with its alkaline bafe: for when nitre is diftilled,

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* There is no more extraordinary natural or chemical fact than the the production of fix fpecies of falt, in the rubbifh of old houfes, each of the alkaline bafes being conftantly united with a peculiar acid. Potafh is always united with the nitric acid, and foda is always combined with the muriatic. There would feem to be fome particular relations between thofe different kinds of primary falts, in confequence of which they mutually felect each other; for why is there no muriate of potafh or nitrate of foda? The fame thing might be obferved of the earthy falts: in fact, there is much more muriate of magnefia and calcareous nitrate, than nitrate of magnefia or calcareous muriate: and this fhows magnefia to have a peculiar affinity with the muriatic, and lime with the nitric acid.—F.

tilled, without any intermediate body being ufed, theq.
is no nitrous acid, but a mixture of vital air with gas
azote, obtained. The reafon of this I take to be, that
when nitre of potafh is diftilled without an intermedium,
the alkali reacts on the acid, and contributes to its de-
compofition; whereas, when this falt ·is heated with a
mixture of fand, the fand, by its tendency to form glafs
by combining with the potafh, prevents the alkali from
reacting on the acid, which therefore efcapes unaltered.
Argillaceous earths likewife decompofe nitre. Co-
loured clay is generally made ufe of for this purpofe.
The diftillers of aquafortis in Paris make ufe of an
earth of this kind. Into earthen retorts, of a peculiar
form, called *cuines*, they put into each two pounds of
nitre, of the fecond boiling, with fix pounds of colour-
ed clay of Gentilly : the retorts are arranged one be-
fide another, in long furnaces known by the name of
galleries; and the neck of each retort enters a bottle
of the fame form, ferving as a receiver. By this means
they obtain at firft a tranfparent liquor, fomewhat acid,
which they call *phlegm of aquafortis*, and afterwards
the acid gradually more and more concentrated. The
refidue is a very hard, red, earthy fubftance, which
ferves for making a kind of mortar. But this experi-
ment by no means proves that clay decompofes nitre
of potafh :—For, 1. The nitre ufed by the diftillers is
very impure, containing a great deal of earthy nitre:
2. The clay which they make ufe of is of a very com-
pound nature, often containing a great quantity of py-
rites, the fulphuric acid of which may poffibly decom-
pofe the nitre. In order that this decompofition may
determine the fact in queftion, it fhould be made with

white

white clay, or rather with alumine. As this earth has not fo great a tendency as fand to unite with the alkali and does not form glafs by combining with this falt, it does not feem capable of effecting fo complete a decompofition of nitre of potafh as fand produces. M. Baumé, however, fays, that he obtained the acid of nitre of potafh by the addition of porcelain and clay baked in ftoneware : but he thinks that the decompofition of the falt was owing to the acid contained in the clays.

Barytes decompofes nitre of potafh, and feparates the alkali. Bergman, in his table of affinities, places this falino-terrene fubftance before the alkalis, and immediately after the nitric acid.

Magnefia, lime, and the alkalis, act not upon nitre. But the acids act in a very diftinct manner on this falt, particularly the fulphuric acid, which has really a greater affinity than the nitric acid with the alkalis. When a quantity of concentrated fulphuric acid is poured on a quantity of dry nitre of potafh, a confiderable effervefcence is produced, and red vapours are feen to arife, which are actually nitrous acid. By performing this operation in a receiver with the retort fitted to it, we may collect this acid : it is known by the name of *fpirit of nitre.* This operation is called in the laboratories, *the diftillation of the fpirit of nitre in Glauber's way*; becaufe Glauber was the firft who gave a plain intelligible defcription of it. The receiver ufed in this operation muft be perforated with a fmall hole, to give vent to the vapours of the nitrous acid. It was remarked, that there was much difficulty in condenfing thefe vapours, and that the procefs was liable to two accidents. The firft was, the lofs of no fmall portion of the

3 *fpirit*

spirit of nitre which escaped through the orifice of the
veffel : the second, the danger to which the operator
was exposed from such extremely acrid and corrosive
vapours.   This procefs was therefore very defective.
Mr Woulfe, an ingenious Englifh chemift, has found
means to obviate thefe inconveniences.   Instead of uf-
ing a receiver perforated with a little hole, he has a-
dopted one with two necks.   Into the extremity of this
veffel, which is fartheft from the receiver, he puts a
tube, one end of which being in an horizontal pofition,
makes a right angle with the other, which is vertical
and inferted into a bottle.   This bottle has in its
fides two orifices; each of thefe receives a fyphon
which paffes into another bottle standing befide the
firft.   The two collateral bottles are joined by means
of a fyphon with two others, of which the lateral a-
pertures remain open.   The firft bottle generally re-
mains empty : the collateral bottles contain a quan-
tity of water, in which the lower and longeft extre-
mity of the tube which communicates between the
two, is immerfed : the upper part of the bottles remains
empty ; and the acid vapour is conducted by the tubes
through the bottles.   By the ufe of this ingenious ap-
paratus, the artift is fecured from all danger, and no-
thing is loft.   The nitrous acid in vapour paffes through
the retort into the firft bottles, and is there condenfed;
and what is not condenfed in the firft paffes into the
fecond bottles, and there unites with the water.   From
the lateral apertures of the laft bottles, there efcapes a
certain quantity of vital air, which may be received
into proper glaffes.   This apparatus, as here defcribed,
poffeffes one advantage worthy of our notice : When
                                                    the

the retort is left to cool at the end of the operation, a
vacuum is produced in the veffels, and the external
air prefling on the water in the outer bottles ftanding
open, forces it through the fyphons into the inner col-
lateral bottles; and from thefe again it paffes into the
middle bottle ftanding neareft to the retort. If the
firft bottle were not empty, or not large enough to con-
tain all the water from the others, the acid liquors
would pafs into the receiver: and as the ftrongeft ni-
trous acid is contained in that veffel, it would be mix-
ed with the liquors from the bottles, and therefore
would not poffefs the required ftrength. This circum-
ftance would be ftill more inconvenient in other in-
ftances of diftillation, of which we are hereafter to
fpeak; becaufe it would not fimply weaken the ftrength
of the product, but would even alter its purity.

In performing this operation in a laboratory, four
pounds of pure nitrate of potafh, melted into cryftal-
mineral, are put into a tubulated ftone retort, placed in
a reverberating furnace; or tubulated glafs retorts may
be ufed in a fand-bath. Two pounds and an half of
concentrated fulphuric acid are poured in at once
through the aperture, and it is then fhut. The appa-
ratus above defcribed, which we fuppofe to have been
prepared and put together on the preceding evening, is
to be inftantly applied and luted to the retort; it is
next to be gradually heated till nothing more comes
over. The difengagement of the gas, and its paffage
into the bottles, ferve to direct the operator in con-
ducting the procefs. If the gas appear to be difengaged
with too much rapidity, the heat : then too violent,
and muft be diminifhed, otherwife the whole mafs in
the

the retort will fwell up and pafs into the receiver: But again, if it pafs too flowly, the fire mutt be increafed to prevent the abforption of the gas. This apparatus is therefore happily formed to direct the artift in the management of his procefs.

The refidue, after this decompofition, is fulphate of potafh, formed by the union of the fulphuric acid with the alkaline bafe of nitre. This refidue is known in pharmacy under the name of *fal de duobus*, or *arcanum duplicatum.* It is ufually a white opaque mafs, half vitrified, and filled with cavities produced in it when it was fwelled by the heat. This falt is ftrongly acid, on account of the quantity of fulphuric acid made ufe of in producing it; and it is the excefs of the acid which caufes the falt to melt, as we have feen under the hiftory of fulphate of potafh. The nitrous acid obtained by this procefs is very red and fuming, becaufe the intenfe heat employed in the diftillation difengages a portion of vital air. As it is always mixed with a certain quantity of fulphuric acid, it is to be rectified by a new procefs of diftillation on a quantity of nitre equal to one-fourth of its own weight. We muft likewife obferve, that the nitre made ufe of on this occafion muft be very pure, in order to afford nitrous acid in fuch a ftate that we may depend upon its effects. That which is obtained from nitre of the fecond boiling, contains muriatic acid, and acts with the folvent power of aqua regia. This acid may be purified of the muriatic acid which it contains by a diftillation judicioufly managed; as is fhown by Meffrs de Laffone and Cornette (*Mem. Acad.* 1781, p. 653 to 656).

The

The concrete boracjc acid decompofes nitre with the help of heat, difengaging from it the nitric acid in a concentrated ftate. It appears to effect this decompofition by means of its fixity; which is the opinion of the academicians of Dijon. Yet it muft alfo be afcribed in part to the mutual attraction between the boracic acid and the potafh bafe of nitre.

Nitre of potafh is much ufed in the arts. It is the principal ingredient in gun-powder; of which compofition we fhall have occafion to fpeak under the article of fulphur. When burnt with various proportions of tartar, it forms the melting matters called *fluxes*, which are ufed in the affaying of metals for melting and reducing metallic fubftances, &c. &c.

. It is often ufed in medicine as a quieting, cooling, refrefhing, diuretic, antifeptic medicine, &c. It is given in any kind of drink, in dofes of—from ten or twelve grains to half a dram and more. Phyficians have daily inftances of its good effects *.

Species

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* Since nitre is a compound of potafh with azote and oxigene, all matters affording thefe three fubftances, will, of courfe contribute to its formation; animal matters, by furnifhing azote; vegetables, as yielding potafh; the air, as fupplying oxigene. It efflorefces on the furface of uncultivated grounds. It is formed on the pafture grounds of cattle. It is difperfed even in the duft of the roads of Spain. Chefnuts fupply a material for its formation. M. Virengue has found, that it is produced in all extracts capable of fermentation, The diftillation of nitrate of potafh, affords 12000 cubic inches of oxigene, for each lib. of the falt: 7 parts of water, diffolve 1 part of nitre at 60° Fahrenheit: and boiling water diffolves a quantity equal to itfelf in weight. 100 grains of the cryftals of nitre contain 30 acid, 63 alkali, and 7 water.—H.

Species IV. *Nitrate of Soda.*

NITRATE of foda, which has been called *cubic, qua-drangular*, and *rhomboidal nitre*, is a perfect neutral falt, refulting from a faturated combination of the nitric acid with foda.

This falt generally appears in pretty large and very regular rhomboidal cryftals. The name of *rhomboidal nitre* defcribes it better than that of *cubic nitre*.

Its tafte is frefh, and rather more bitter than that of nitre of potafh.

Fire decompofes this as well as the preceding falt; but it decrepitates, and does not melt fo eafily as the other. It affords a mixture of vital air with gas azote, with an alkaline refidue like nitre of potafh.

It is rather more fubject than nitre of potafh to alteration from the air, and attracts moifture, though not with much force.

It diffolves in cold water even more readily than the former falt; for two parts of water, at the ordinary temperature of 60°, are fufficient to diffolve one part of nitrate of foda. Boiling water fcarce diffolves it in a greater proportion : and therefore, when we wifh to obtain it in regular cryftals, the folution muft be flowly evaporated. If a tolerably clear lixivium of this falt be fet afide in a dry place,—at the end of fome months it is found to contain rhomboidal cryftals, fix or eight lines, and fometimes near an inch long. This is ufually the happieft procefs for cryftallifing falts that are as foluble in cold as in warm waters.

Nitre of foda detonizes on burning coals, and in-
flames

flames any combuflible body heated along with it,— rather more flowly than nitre of potafh.

Siliceous earth difengages the nitric acid, and unites with its bafe to form glafs. Clay alfo feparates the acid, giving as a refidue a kind of frit, which becomes porous and opaque after being expofed to a ftrong heat.

Barytes decompofes it, and leaves the foda pure. Magnefia and lime produce no fenfible alteration upon it.

Potafh having more affinity than the bafe of this falt with the nitric acid, attracts it to itfelf, and forms with it nitre of potafh. We obtain conviction of the truth of this fact by a very fimple experiment. If a boiling faturated folution of nitre of foda be divided into two portions, and into one of thefe there be thrown a quantity of cauftic potafh, the portion which received this addition will depofite, when it cools, prifmatic cryftals of nitre of potafh ; while the other into which there was no potafh put, will exhibit no cryftals at all, becaufe nitre of foda cryftallifes only by a very flow evaporation.

If concentrated fulphuric acid be poured upon nitrate of foda, it will difengage the nitrous acid with effervefcence. Nitric acid is obtained by a diftillation of this mixture, as well as from nitre of potafh. The other mineral acids act no more on this falt than on the foregoing.

The neutral falts which has been already examined, fulphate of potafh and foda, and nitrate of potafh, produce no alteration on nitrate of foda. When thefe falts are all diffolved in the fame water, they cryftal-

lize feparately, each in its ordinary way: Nitrate of
potafh and fulphate of foda, by cooling; fulphate of
potafh and nitre of foda, by evaporation. From all
thefe properties it appears, that nitrate of foda dif-
fers from nitrate of potafh only in its form, its tafte,
its flight tendency to deliquiate, its being of eafier fo-
lution, its cryftallifing by evaporation, and chiefly by
its fufceptibility of decompofition by potafh.

. . Nitrate of foda has not been yet found in nature.
It is always a product of art, and is formed in the five
following ways: 1. By the direct combination of the
nitric acid with foda. 2. By decompofing with this
alkali, earthy nitrates, ammoniacal nitrate, and metal-
lic nitrates. 3. By decompofing muriate of foda with
the nitric acid for an intermedium. 4. By decompof-
ing fulphate of foda by the fuming fpirit of nitre. 5.
By decompofing fuch nitrous folutions of metals as are
fufceptible of it, with muriate of foda: In this inftance,
in proportion as the muriatic acid combines with the
metal, feparating from it the nitric acid, the feparated
acid combines with the foda, which has alfo deferted
the acid with which it was before united. All thefe
decompofitions will be particularly defcribed in the
refpective hiftories of the falts which are liable to
them.

Nitrate of foda might be employed for the fame pur-
pofes as nitrate of potafh. But as it does not produce
all the effects of that falt, doubtlefs on account of its
having a greater affinity with water, it is not made ufe
of in the arts. Befides, as it is not found in nature,
but is merely a product of art, no attempt has been
made to apply it to any particular ufe. A fufficient

<div align="right">number</div>

number of experiments has not yet been made on this falt to make us acquainted with all its properties *.

Species V. *Muriate of Potaſh.*

MURIATE of potaſh, which was formerly called *fe-brifuge falt of Sylvius*, is a faturated combination of the muriatic acid with potaſh. It has been improperly named *regenerated marine falt;* for the nature of its bafe renders it different from that falt. Its cryſtals are cubic, but always of a confufed appearance, and ra-ther an irregular form. Its taſte is faline, pungent, bit-ter, and difagreeable· When expofed to fire, it de-crepitates; that is to fay, its cryſtals break into fmall pieces; which is occafioned by the fudden rarefaction of the water which enters into their compofition. If fuffered to remain in the fire after decrepitation, it melts and is volatilifed, but not decompofed. It may be ufed as a flux for earths and metallic fubſtances. Its chief ufe in fuch cafes is to cover the matters to be melted, and by this means fix the action of other fluxes employed, hindering them from becoming vo-latile, and preventing fuch alterations as might be oc-cafioned by the accefs of air.

Muriate of potaſh is fubject to little alteration from the air, as it fcarce attracts moiſture.

About three parts of cold water are neceffary to maintain in folution one of this falt; nor has hot wa-ter any greater power of diffolving it. For this reafon a flow evaporation is ufed, to give it in cryſtals. It is

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one

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* 100 grains nitrate of foda, contain 28.80 acid, 50.09 alkali, 21.11 water.—*H.*

, one of thofe falts which it is very difficult to obtain in
regular cryftals of a certain fize.

Clay feems to decompofe it in part: for muriatic
acid may be obtained by diftilling this falt with the
clays in the neighbourhood of Paris. That operation
indeed affords but a fmall quantity of the acid, and its
refult is very different from that which nitrate of potafh
affords. Sand is alfo known to act in the fame manner
as clay on muriate of potafh.

Barytes, according to Bergman, feizes the acid, leav-
ing the potafh in a feparate ftate. Magnefia and lime
produce no alteration on this falt.

The fulphuric and the nitric acids difengage the
muriatic with effervefcence *. This phenomenon is
the more ftriking, if the potafh be dry. Muriate of
potafh, after decrepitating, and lofing the water of its
cryftals, gives a very confiderable effervefcence with
the concentrated fulphuric acid, and the. mixture be-
comes very warm. Where thefe decompofitions are
performed in retorts, muriatic acid paffes into the re-
ceiver,

* We have already obferved, when fpeaking of the decompofitio
of nitre of potafh by the concentrated fulphuric acid, that the nitrous
acid is then difengaged with a lively effervefcence. We find the mu-
riatic acid exhibiting the fame phenomenon; in a much more eminent
degree indeed, becaufe this acid has a very ftrong tendency to affume
the gafeous ftate. This is the general caufe of all effervefcences, the
nature and diftinctions of which have, till of late, been but very imper-
fectly known. It was formerly thought that they were owing to the
difengagement of air : we now know them to be produced, not by air,
but by all bodies which have any tendency to the ftate of aëriform ag-
gregation; and thus we have fhown, that the ebullition of water may
be confidered as a fort of effervefcence. As this truth needs to be
frequently repeated, in order that it may become generally known, we
fhall take occafion to recur to it feveral times when treating of the dif-
ferent neutral falts which admit of decompofition by acids.—F.

ceiver, and the refidue in the retort is found to be
fulphate of potafh,—if the fulphuric acid was employ-
ed to effect the decompofition ; but if the nitric acid
was ufed, aqua regia is obtained in the receiver, and
the refidue is nitre of potafh. The boracic acid likewife
decompofes muriate of potafh by diftillation, difengag-
ing the muriatic acid. As all of thefe operations are
done with muriate of foda or marine falt, we fhall give
a more particular account of them under that article.
Neither the fluoric nor the carbonic acid acts in any way
on muriated potafh.

Neither fulphate nor nitrate of potafh or foda acts
upon this falt. When all are diffolved in the fame wa-
ter, each of them is cryftallifed feparately and in its own
way.

Muriate of potafh is frequently met with in nature ;
but never much of it together. It is found in fea wa-
ter, and in the water of falt fprings; fometimes, though
not often indeed, it is met with in the fame places
where nitre of potafh is found ; it is alfo found in afhes
of vegetables, and in fome animal humours. Art pro-
duces it, 1. By a direct combination of the muria-
tic acid with potafh ; 2. By decompofing earthy, am-
moniacal, or metallic muriates by the fame alkali ;
3. By decompofing fulphate or nitrate of potafh, by
means of the muriatic acid, as M. Cornette has
fhown.

This neutral falt was formerly adminiftered as an ex-
cellent febrifuge. But it poffeffes not this property other-
wife than in common with all bitter falts. Sulphate of
potafh or foda is now preferred to it.

Muriate of potafh is applied to no ufe in the arts.

E e 3 Its

Its difagreeable tafte hinders it from being ufed, like muriate of foda, for feafoning. But it has all the chemical properties of that falt ; and the only difference between them is, that muriate of potafh has a bitter tafte, is more difficult of folution, is unalterable by the air, and is irregularly cryftallifed. We fhall therefore infift no more upon its hiftory *.

Species VI. *Muriate of Soda.*

MURIATE of foda, better known under the name of *culinary* or *common falt*, is a perfect neutral falt, formed by a faturated combination of the muriatic acid with foda. The reader will perceive that the nomenclature which we have hitherto ufed, renders a definition of the nature of thefe neutral falts almoft unneceffary ; as the name of each is expreffive of its nature.

This falt abounds in nature more than any other fpecies. It is found in vaft maffes in the interior parts of the earth, in Spain, Calabria, Hungary, and Mufcovy, but more efpecially at Wieliezka in Poland, near the Crapack mountains †. In the laft of thefe places the

<div style="text-align:right">mines</div>

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* 100 grains of muriate of potafh, contain 29,68 acid, 63,47 alkali, and 6,85 water.—H.

† It is found alfo in *Switzerland* and *Tyrol*, and at Northwich in Chefhire in England: and it has been inferred from the exiftence of the falt fprings in *Lorraine* and *Franche-Comté ;* that there are falt mines in the bowels of the earth, in thefe diftricts of the French territory.—Strata of foffil falt probably owe their origin to the natural deficcation of lakes of falt water, or from the precipitation of the falt, by a natural procefs in fuch lakes. For a good account of the manner of working falt mines, See Memoire fur le Sel Marin, par *M. Haffenfratz ; les de Chimie,* tom. XI. p. 65.—H.

mines are of vaft extent, and the muriate of foda is found in prodigious maffes. This falt, as it exifts in the earth, is generally irregular, and feldom cryftallifed ; it is ufually more or lefs white, but fometimes coloured : in this ftate it is called *fal-gem*, having often the tranfparency of the cryftals known under that name. The waters of the fea, as well as of fome lakes and rivers, contain this falt. From thefe waters it is obtained by four general proceffes.

The firft is fpontaneous evaporation by the heat of the fun. This method is ufed in our fouthern provin- ces, in Languedoc, at Peyrac, Pecais, &c. Trenches are cut on the fea fhore, and very compactly lined with clay : within thefe trenches little walls are built, dividing them into certain compartments, yet leaving a general communication. When the tide flows, the trenches are filled with water, which is retained in them by the walls forming a kind of fluice-gates. Care is taken that the layer of water retained be thin enough to be readily evaporated by the rays of the fun. As foon as a faline pellicle is formed, it is broken, and the fragments fall to the bottom ; and the fame procefs is repeated till the water be entirely evaporated. The falt is then gathered with rakes, and laid in heaps to dry. This falt contains a mixture of all the other falts that exift in a ftate of folution in fea-water, fuch as fulphate of foda and magnefia, muriate of magnefia and lime : it is alfo contaminated with a portion of clay from the bottom of the trench : and, laftly, fmall globules of iron and mercury are found in it. The exiftence of the latter in it may be eafily fhown by leaving a fmall piece of gold among the falt for fome time : it becomes evi-

dently

dently whiter. This falt being very impure, is known under the name of *fel de gabelle.*

In the northern provinces of France, in Normandy and Brittany, this falt is prepared by an artificial eva- poration by fire. In Avranches they take the quickfands among which the fea water has depofited faline cryftals, and wafh them in the fmalleft quantity poffible of fea water, in order that no more may be ufed than what is neceffary to diffolve the falt : This falt water is then put into lead veffels, and evaporated to drynefs. This falt is very white, and purer than that prepared by eva- poration in trenches. Guettard has given a careful def- cription of the whole procefs in the Memoirs of the Aca- demy for the year 1758.

In Lorraine and Franche-Comté there are many falt fprings. The quantities of muriate of foda which thofe fprings contain in proportion to the quantity of water are various. At Montmorot, in the laft of thefe provinces, both fpontaneous evaporation and evapo- ration by fire are ufed in the preparation of this falt. For that purpofe, the well-water is conveyed by pumps into a large refervoir placed at the top of a fhed of a peculiar conftruction. Under this fhed are fufpend- ed boards covered with little faggots of thorns. The water falling upon thefe faggots through fmall cocks, is divided into very minute drops : and as it thus expofes a great deal of furface to the air circulating rapidly under the fhed, nearly two-thirds of it is evaporated. What is depofited on the faggots is ful- phate of lime or felenite. And when the liquor, upon trial with an inftrument for the purpofe, is found to be charged with falt to a certain degree, it is conveyed

into

into large iron boilers fupported by bars of the fame metal, which crofs the bottoms of the veffels, and reft on pieces of wood placed on each fide. Thefe boilers which are called *floves*, are very large and fhallow, and hold an hundred hogfheads * of the falt water. They are then urged with a ftrong fire. When the water boils up in large bubbles, it is at firft muddy, and foon depofites an ochreous earth on its furface in the form of a fcum. A falt, which is fcarcely foluble, and is called by the workmen *fcblot*, is next feparated : This falt is nothing but fulphate of lime mixed with a little muriate of foda, fulphate of foda, and earthy muriates. It is conveyed by the circulation of the boiling liquor into little troughs placed round the fides of the boilers for the purpofe. Thefe troughs are taken out, and cleared from time to time, till a great quantity of fmall cubical cryftals called by the workmen *pieds de mouches*, are obferved floating on the furface of the liquor. They are then taken away for the laft time. The fire is diminifhed, and the muriate of foda is taken off with ladles as faft as it is cryftallized. The evaporation is thus continued as long as the water continues to afford cryftals. The falt thus obtained is in larger or fmaller cryftals, according to the flownefs or rapidity of the evaporation. The water which remains when cryftals are no longer obtained, is called *mother water*, and contains earthy muriates †.

<div align="right">Wallerius</div>

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* *Muids*, containing each 380 French pints.

† There is a neutral falt prepared at Montmorot, known under the name of *Epfom falt of Lorraine;* but it is only fulphate of foda, or Glauber falt, the cryftallization of which has been difturbed. It is

<div align="right">diftinguifhed</div>

Wallerius gives an account of a fourth procefs for obtaining falt from fea water, which is practifed in the north. The water is confined in trenches on the fhore; as it forms but a fmall ftratum, the cold foon penetrates through and freezes it. But as that portion neceffary for the folution of the falt contained in the whole quantity of water cannot be converted into ice, what remains fluid contains all the falt, and is fo concentrated that the moft moderate heat caufes it to afford muriate of foda in cryftals: it is then conveyed into leaden boilers, and evaporated by fire.

The cryftals of muriate of foda are very regular cubes of a larger or fmaller fize, in proportion as the evaporation has been flower or more rapid. They ftick together in clufters, forming a kind of ladders, or rather hoppers. Rouelle the elder obferved this phenomenon, and has given an accurate defcription of it in his Memoirs on Cryftallization. Bergman has given a very ingenious explanation of this fact.

Every body knows the tafte of this falt, which is not difagreeable.

When expofed to a brifk heat it burfts and flies into pieces. This phenomenon is called *decrepitation.* It is owing, as we have already obferved when fpeaking of fulphate and muriate of potafh, to the fudden rarefaction of the water on which the cryftailization depends. When all the water is thus evaporated, the decrepitation ceafes, and the falt appears in a powder.

If

distinguifhed from genuine fulphate of magnefia and Epfom falt, fuch as comes from England, by its efflorefcing in the air, while the latter deliquiates.—F.

If we continue to urge it with a ftrong heat, it melts after becoming red-hot. If poured in this ftate on the plane furface of a piece of marble, it congeals into a kind of cryftal mineral; but it has not fuffered the leaft alteration, for it may be reftored to its original form by foluti-n in water. Fire therefore does not decompofe it: if maintained for fome time in fufion, it is at length volatilized, but ftill without alteration. The moft intenfe heat is requifite to bring it into this laft ftate.

Muriate of foda when pure fuffers no fenfible alteration from air; it rather becomes dry than acquires moifture. It never indeed attracts moifture but when it contains a mixture of muriates with earthy bafes, fuch as in *fel de gabelle.*

It diffolves very readily in water: three parts of the fluid are fufficient to maintain one of this falt in folution. Three ounces and an half of water will entirely diffolve an ounce of the falt. Boiling water does not diffolve it in a greater proportion than cold water; only the folution is rather fooner effected with the help of heat. A very flow evaporation is requifite to give this falt in cryftals. The cryftallization begins with the formation of a number of fmall points on the furface of the liquor, which are gradually united in a pellicle, more or lefs thick; inftead of being cubic, the cryftals are fometimes fquare hollow pyramids, refembling hoppers. Rouelle the elder, who paid the greateft attention to all the phenomena of this cryftallization, obferved the hoppers to be formed in the following manner. When a cube is formed, the little folid finks a fhort way beneath the furface of the water; a fecond is foon

formed,

formed, and connected with the firft on one of its fides;
and the fame phenomenon takes place on the three o-
ther fides of the cube. This aggregation of cubic cry-
ftals naturally produces narrow inverted pyramids.
When thefe are large they fink to the bottom. If the
falt diffolved was very pure, what remains of the water
after it has been evaporated till it would afford no more
cryftals, is entirely without any faline matter. The
water of the fea and of falt fprings always contains falts
with an earthy bafe. The earth may be precipitated
by foda, as we fhall have occafion to mention when
fpeaking of earthy neutral falts. Such is the method
ufed for obtaining muriate of foda in a ftate of great
purity.

Muriate of foda appears to contribute to the fufion of
glafs. It conftantly occupies the upper part of the pots
in which this matter is melted, and conftitutes the
greateft part of glafs-gall.

It is ufed for vitrifying the exterior furface of cer-
tain pottery wares, and for giving them a kind of cover,
by melting down part of their fubftance with the force
of heat communicated through the falt. This is eafily
effected by throwing a certain quantity of muriate of
foda into the furnace. It is volatilized, and by this
means fpread over the furface of the earthen ware,
which, by its intenfe heat, it caufes in part to melt.
This is the Englifh way of glazing.

Siliceous earth does not alter this falt, though it ap-
pears to promote its fufion.

Pure clay acts with much lefs force on muriate of
foda than on nitres. When diftilled with this falt, it
affords but a very fmall quantity of a weak phlegmatic
                                                    acid.

acid. Diftillers of aquafortis, it is true, obtain in this manner the muriatic acid called *fpirit of falt:* but they make ufe of *fel de gabelle* for the purpofe ; and it contains various muriates with an earthy bafe; befides, the clay which they ufe is very impure, and of a deep colour.

According to Bergman's experiments, barytes decompofes muriate of foda, as well as the other alkaline falts; neither lime nor magnefia produces any alteration on muriate of foda. Perhaps thefe two falino-terrene fubftances, in combination with the carbonic acid, might feparate the component principles of muriate of foda by a double elective attraction.

Cauftic potafh decompofes muriate of foda, having a greater affinity than foda with its acid. A folution of muriate of foda mixed with potafh, gives by evaporation muriate of potafh, and the mother water contains pure infulated foda.

Acids act in a very diftinct manner on muriate of foda. When concentrated fulphuric acid is poured on this falt, it caufes a very confiderable motion and a very lively heat. A violent effervefcence is obferved on the occafion *, which arifes from the difengagement of the muriatic acid under the form of gas. This aëriform acid may be diftinguifhed after it has efcaped into the atmofphere, as it forms a white vapour with the water in the air, and has, when the vapour

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* Effervefcence is as obfervable in this operation as in the union of the fame acid with lime and alkali faturated with carbonic acid. It takes place, therefore, whenever any body feparated from a ftate of combination is volatilized under a gafeous form : and it may be produced by the carbonic, the muriatic, the nitric, the fulphureous, and the fluoric acids, &c. It muft not be afcribed to the difengagement of air.—F.

is very much diluted, a pungent fmell not unlike that
of faffron. A confiderable quantity of muriatic acid
gas may be obtained by performing the operation with
a pneumato-chemical machine provided with mer-
cury. Glauber was the firft who obferved that the
acid of marine falt might be obtained by decompofing
the falt with fulphuric acid, and defcribed the pro-
cefs for obtaining it; on which account this has re-
ceived the name of *Glauber's fpirit of falt.* It was in
examining the refidue of this operation that he difco-
vered his admirable falt to which we now give the
name of *fulphate of foda.*

Almoft all writers on the fubject, direct the diftilla-
tion of this falt to obtain the muriatic acid, to be per-
formed by putting a quantity of it into a tubulated
ftone-retort, and pouring in at the orifice half its
weight of concentrated fulphuric acid : A confiderable
quantity of acid vapour is immediately difengaged,
which paffes by the extremity of the retort into two
balloons prepared to receive it : One of thefe vef-
fels has a little hole to let the vapours efcape, fo that
they may not burft the veffels. In this operation, as
well as in the diftillation of the nitrous acid, a confi-
derable quantity of the pureft muriatic acid is loft,—
efcaping in a gafeous form through the hole of the bal-
loon ; and the vapours of this acid being fo very corro-
five, are exceedingly troublefome to the operator. To
obviate in part this inconvenience, M. Baumé puts a
quantity of water into the retort ; and the water be-
ing volatilized in the balloon, abforbs part of the mu-
riatic acid gas : But as the water is much lefs volatile
than the acid, there is ftill a confiderable quantity of

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the acid loft. Mr Woulfe has found means to obviate all thefe inconveniences, and to procure the muriatic acid in the ftrongeft and moft concentrated ftate of which it is capable, by an expedient directly contrary to M. Baumé's. Inftead of volatilizing the water, to make it abforb the vapours of the muriatic acid, he cau- fes the gas to pafs through that liquid by the apparatus which we defcribed under the article of nitre.

For every two pounds of muriate of foda and one of the concentrated fulphuric acid that are mixed in the retort, eight ounces of diftilled water are put into the collateral bottles. The muriatic acid gas is conducted through the tubes into the water in the bottles, and there diffolved. The water, as it combines with the gas, is heated almoft to ebullition, and abforbs a quan- tity equal to itfelf in weight. When fully faturated, it ceafes to abforb the gas and becomes cold ; but the gas pafling into the fecond collateral bottles, is again immerfed in the water which they contain, and heats and faturates it.

This very ingenious procefs being perfectly confift- ent with the known properties of the muriatic acid gas, poffeffes a number of advantages. 1. It fecures the operator from the inconveniences to which he is expof- ed when the acid is diffufed through the open air. 2. It prevents the very confiderable lofs of the acid, which was unavoidable in M. Baumé's procefs. 3. It gives the muriatic acid in a ftronger, more concentrated, and more fuming ftate than we could poffibly have it other- wife. 4. The acid obtained this way is extremely pure, being entirely formed of gas that has been diffolved in water. It is on this account extremely white; whereas

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that

that which was formerly obtained in the laboratory was always of a citron colour; a circumstance which even led chemists into a mistake, for they considered this colour as a characteristic property of the acid. That portion of the liquid acid which is in this process condensed in the receiver is yellow, and contaminated with extraneous matters conveyed into it by the water of the mixture, as happened to the whole of what was obtained in the old way. 5. The new method directs the operator what strength of fire to use, and how to conduct his operation by the slower or quicker passage of the gaseous muriatic acid through the water in the bottles. 6. Lastly, what is of more importance than any of its other advantages, it enables us to determine the precise quantity of acid contained in any neutral salt, as not a particle of the acid separated is lost.

The nitric acid likewise decomposes muriate of soda; but, being volatile, it ascends and unites with the acid of this salt. From this union results the mixed acid known by the name *nitro-muriatic acid*, or *aqua regia*.

Baron has discovered that the boracic acid, with the help of heat, disengages the acid from muriate of soda. The residue, after this distillation, is genuine borax of soda in a very pure state.

Neither the carbonic nor the fluoric acid acts in any distinct manner on muriate of soda.

None of the neutral salts hitherto described by us acts upon this salt. When sulphate and nitrate of potash and soda and muriate of potash are dissolved in the same water with muriate of soda, each of these salts crystallises by itself, and in its own way. Muriate of soda is among the first which are separated in the pro-

grefs of the e poration, and it mixes with a little of
the fulphate and muriate of potafh; but the fulphate
of foda and nitrate of potafh remain longer in folution,
and are cryftallifed by the cooling of the liquid. On
this account, in Lorraine, the mother-water, from
which marine falt has been obtained, is put into veffels,
and ftirred while it cools, with ftaves for the purpofe;
which caufes the fulphate of foda to cryftallife in a con-
fufed manner, in fmall needles, refembling thofe of ge-
nuine Epfom falt, or fulphate of magnefia.

The ufes of muriate of foda are extremely various :
It is employed, 1. For glazing fome kinds of earthen
ware by occafioning a flight fufion of their exterior fur-
faces. 2. By glafs-makers, for whitening and purify-
ing glafs. 3. In affaying metallic ores, as a flux to the
matters of which the fcoriæ are formed, to facilitate the
precipitation of the metals, and to defend them from
the contact of the atmofphere, fo that they may fuffer
no change from the air.

At prefent we find it neceffary to apply it to a pur-
pofe of ftill more importance than any or thefe,—for the
extraction of foda, which is becoming every day more
fcarce, and is of effential ufe in many of the arts.
Several people in England poffefs the fecret of obtain-
ing foda from marine falt in the great way *, and prac-
tife it in confiderable extent.

Some chemifts have thought litharge capable of de-
compofing muriate of foda by fimple maceration and
cold. It would appear that, in confequence of its con-

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* We underftand that the extraction of foda from marine falt is
not practifed in England to fuch extent as M. Fourcroy feems to
think.—H.

taining carbonic acid capable of attracting foda, and forming with the muriatic acid an infoluble falt, eafily feparable from the alkaline lixivium, it muft act by a double elective attraction ; but the experiments which I have made on this point, convince me that the procefs is inadequate to the purpofe. Scheele obferved, that iron immerfed in a folution of muriate of foda is coated with foda faturated with carbonic acid. He treated fulphate and nitrate of foda in the fame manner, with the fame fuccefs. He difcovered, that quicklime mixed with muriate of foda, if the mixture were depofited in a damp cellar, afforded an efflorefcence of foda and calcareous muriate. This fact was firft communicated to the public by Cohaufen in the year 1717. M. de Morveau has proved, that thefe decompofitions are effected by means of the carbonic acid ; for if a folution of fulphate and muriate of potafh be poured upon lime-water precipitated by the carbonic acid, it becomes clear and tranfparent ; but when water containing carbonic acid, is poured on a folution of thofe falts mixed with lime-water, no precipitation takes place. Thefe facts are fo many *data*, on which we muft proceed in attempts to obtain foda from marine falt, and to form extenfive eftablifhments for the purpofe.

Muriate of foda is ufed as feafoning to the articles of our food, and corrects their infipidity. It likewife facilitates digeftion, by beginning the putrid alteration of the fubftances we ufe for aliment. Though it be fully proved by the experiments of Pringle, Macbride, &c. that when mixed in a pretty large proportion with animal fubftances, it retards putrefaction, and is powerfully

fully antiſeptic, like moſt other ſaline matters; yet it
acts in a very different manner when mixed with the
ſame ſubſtances in a very ſmall proportion, cauſing
them to paſs more readily into a ſtate of putrefaction.
This is proved by the experiments of the author of the
Eſſays on the Hiſtory of Putrefaction, and by M. Gar-
danne's experiments.

The ſalt is not leſs uſeful in medicine. In apoplec-
tic and paralytic caſes, &c. it is put into the mouth,
and uſed externally in baths, as an excellent ſtimulant.
In moſt caſes it is a powerful diſcuſſive. It is ſtrongly
recommended by Ruſſel *(de Tabe Glandulari)* for lym-
phatic tumours, occaſioned by a ſcorbutic habit. I
have myſelf preſcribed it ſucceſsfully for ſeveral diſ-
eaſes of that kind. It is purgative when adminiſtered
in doſes of ſeveral drams. As the moſt impure ſalt is
commonly uſed on all theſe occaſions, its effects are in
part to be aſcribed to the calcareous and magneſian
muriates which it contains *.

F f 2 Species

* The water of the Baltic ſea is ſaid to contain $\frac{1}{64}$ of its weight of
ſalt; the water of the ſea between France and England contains $\frac{1}{72}$ of
its weight of ſalt. On the coaſts of Spain, the water of the ſea has
$\frac{1}{16}$ of ſalt. Between the tropics, the ſea-water is ſaid to have from $\frac{1}{4}$
to $\frac{1}{11}$ of ſalt. The *Jeltonic* ſalt water lake, in the Ruſſian dominions,
was once almoſt ſolid with ſalt, ſo that heavy waggons were driven up-
on it as upon ſtrong ice. But, in the year 1757, the proportion of the
water began to increaſe. And it has ſince increaſed ſo much, as to
form now within the baſon, only a lake ſtrongly impregnated with
ſalt.—H.

Species VII. *Borax of Soda, or Super-faturated Bôrate of Soda* *

B o r a x of foda, or common borax, is a neutral falt, formed by the combination of the boracic acid with foda. We get this falt from the Eaſt Indies; but its hiſtory is very little known. We know not certainly whether it be a product of nature or of art †. If the difcovery of the boracic acid exiſting in a ſtate of folution in the waters of feveral lakes in Tufcany, a fact which we mentioned in the hiſtory of that acid, give us reafon to think borax a product of nature, a variety of facts which we ſhall hereafter mention, concur to ſhow that this falt may be alfo formed by certain artificial proceſſes, as well as nitre.

Borax of foda appears in commerce in three different ſtates. In the firſt, it is crude borax, *tinckal* or *chryfocolle*. This we get from Perfia; it is in greeniſh maſſes which feel greafy, or in opaque cryſtals, coloured like green leeks, which are prifmatic figures of fix faces, terminating in irregular pyramids. There are even two kinds of thefe greeniſh cryſtals, differing from

<div align="right">each</div>

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* Hitherto we have begun with examining the neutral falts formed by the union of the acids with potaſh. But, in fpeaking of thofe into which the boracic acid enters, we are obliged to begin with that which has foda for its bafe, for it is the only one with which we are well acquainted.—F.

† Kirwan, in his mineralogy, page 206. informs us, that it is dug out of the earth in the kingdom of Thibet, in a cryſtalline form. In the Philofophical Tranfactions for the year 1787, we are informed by a letter from Mr Blane, dated at Lucknow, that the borax of Thibet is formed in a certain valley in that country, by the co-operation of fnow and the waters of a lake in the middle of the valley, with a faline matter which abounds over the valley.—E.

each other in fize. This falt is very impure, a great many extraneous fubftances being intermixed in it.

The fecond fpecies is known by the name of *China borax.* It is rather more pure than the former: it appears in the form of fmall plates, or in maffes irregularly cryftallifed, and of a dirty white colour : it difplays the beginnings as it were of prifms and pyramids confounded together without any fymmetrical arrangement. The furfaces of thefe cryftals are covered over with a white duft, which is thought to be of an argillaceous nature.

The third fpecies is Dutch or refined borax. It appears in fragments of cryftals, tranfparent and tolerably pure : pyramids with a number of faces are obferved in it ; but their cryftallifation appears to have been interrupted. This form affords a certain indication of the manner in which the Dutch purify this falt ; it is by folution and cryftallifation.

Laftly, It is prepared at Paris by Meffrs Lefguillers, druggifts in Lombard-Street : and their purified borax is no way inferior, perhaps even fuperior, in purity to the Dutch borax.

Befide thefe four kinds of borax, M. la Pierre apothecary in Paris has imagined it to be formed in a mixture of foap-fuds with dirty kitchen-water, which a certain individual preferves in a fmall trench, obtaining from it at the end of a certain time genuine borax in beautiful cryftals. But this fact, though firft communicated to the public ten years fince, has not received confirmation *.

<div align="center">F f 3</div>

We

* Ten years, at the date of the publication of the 3d edition of this work.—H.

We are ftill ignorant therefore in what manner bo-
rax is formed ; only it appears to be produced in ftag-
nant waters containing fat matters.   Some authors af-
fure us, that it is artificially compofed in China, by
mixing in a trench, greafe, clay, and dung, in-alter-
nate layers, watering this collection of matters at pro-
per times, and leaving it untouched for feveral years.
At the end of this time, by forming thofe matters into
a lixivium, and evaporating the lixivium, crude borax
is obtained.   Others would perfuade us, that it is got
out of water filtered through copper ore.   M. Baumé
pofitively afferts that the former of thefe proceffes fuc-
ceeded very well with him. *Chem. Eper. Tom. II.
page* 132.

   Purified borax appears under the form of fix-fided
prifms, two of the fides larger than the reft, with tri-
hædral pyramids.   It difplays many varieties in its
cryftallifation.   Its tafte is ftiptic and urinous.   It
communicates a green colour to fyrup of violets, on ac-
count of its containing an extraordinary proportion of
foda.   We leave it in poffeffion of the name of borax,
in order to diftinguifh it from genuine *borate of foda*,
which is faturated with the boracic acid : we likewife
call it *borax fuper-faturated with foda*, to indicate the
nature of the combination.

   When expofed to the action of fire, the water of its
cryftallifation caufes it to melt with great rapidity ; it
gradually lofes that water, and fwells to a confiderable
bulk.   It is then in the form of a light, porous, and
very friable mafs, known by the name of *calcined bo-
rax*.   The caufe why borax of foda increafes in bulk,
and affumes a lamellated porous form, on being cal-
cined,

cined, is, that the water which is difengaged into a va-
porous ftate, raifes to the furface a portion of the faline
fubftance half dried, and in light thin pellicles; and
the bubbles in which it rifes, making their way out at
the furface, the pellicles become entirely dry, and are
arranged one above another with interftices between
them. Calcination produces no alteration on borax of
foda, as to its component parts: it lofes, in undergoing
this procefs, nothing but the water which mixed with
it in cryftallifation, nearly in the proportion of fix ouñ-
ces to the pound. We can reftore to it its original form
by diffolving it in water, and caufing it to cryftallife
anew. But if after it has been calcined, we expofe it
to a continued heat, it melts on becoming red-hot into
a very fufible tranfparent greenifh glafs; which is ful-
lied by expofure to the air, and melts in water. Even
fufion produces no change of nature on borax; we
can caufe it to refume its original appearance, with
all its peculiar properties, by folution and cryftalli-
fation.

Air effects no alteration on this falt: it makes it ef-
florefce indeed at the furface by depriving it of part of
the water of its cryftallifation. But this efflorefcence
does not take place in the fame manner on all the feve-
ral kinds of purified borax of foda. The borax of
China gives a much flighter efflorefcence than Dutch
borax. Dutch borax likewife gives a more copious ef-
florefcence than the borax purified in Paris. This flight
difference depends no doubt on the different proceffes
adopted for purifying it; on the manner in which its
cryftals contain water, according as they have been more
flowly or quickly; and perhaps too on the different

proportions

proportions of foda, and the boracic acid, which enter into its compofition.

Borax of foda diffolves very readily in water : twelve parts of cold water are neceffary to diffolve one of this falt ; half that quantity of boiling water will produce the fame effect. It is obtained in cryftals by cooling the folution ; but the moft beautiful and regular cry- ftals are formed in the mother-water, when it is left to evaporate flowly, with the ordinary temperature of the atmofphere.

Borax of foda ferves for a flux to filiceous earth, and joins with it to form a very fine glafs. It is ufed in the preparation of artificial precious ftones.

It likewife caufes clay to vitrify, but with much more difficulty, and more imperfectly. This is the rea- fon of its fticking to the crucibles in which it is put to melt.

We are rather unacquainted with the action of pure barytes and magnefia on borax of foda. Berg- man, however, ranks thofe two fubftances before the alkalis in the tenth column of his table of af- finities ; which fhows that he thinks them capable of decompofing this falt : But in his differtation, he fays, that the affinities of ponderous earth and magnefia with the boracic acid are not yet exactly known.

Lime has actually a greater affinity than foda with this acid. Lime-water precipitates a folution of this falt ; but to make it decompofe it entirely, we muft boil quicklime and borax of foda together : an almoft infoluble faline combination of lime with the boracic acid

Acid is then depofited, and the cauftic foda is left in fo-lution in the water.

Potafh appears to decompofe borax of foda as well as all other neutral falts with a bafe of mineral alkali. Ammoniac produces no fort of alteration on this falt.

The acids act on borax in a very diftinct manner. If into a boiling folution of borax of foda you pour a quantity of concentrated fulphuric acid, taking care to give the liquor a very fmall excefs of the acid, you may obtain from this mixture, by filtrating and cooling it, a very copious precipitate in fmall bright fcales. This precipitate is boracic acid, and by wafhing it in diftilled water, and drying it in the air, it is rendered very pure. By evaporating the folution thus prepared and leaving it to cool, we obtain from time to time new quantities of boracic acid. At laft, the product is ful-phate of foda, formed by the union of the fulphuric acid made ufe of on the occafion, with the alkaline bafe of borax.

The nitric and the muriatic acids decompofe borax of foda in the fame manner, becaufe they, as well as the fulphuric acid, have more affinity with foda than the boracic acid has. The laft evaporations of thefe mixtures afford nitrate or muriate of foda. The difco-very of the boracic acid feems to belong to Beccher, but has been ufually afcribed to Homberg, he having in the Memoirs of the Academy for the year 1702, gi-ven the firft accurate defcription of a procefs for ob-taining it. That chemift obferved this falt to be fubli-mated in the diftillation of a mixture of fulphate of cal-cined iron with borax of foda and water. Imagining the firft of thefe matters to contribute greatly to its

formation,

formation, he gave it the name of *narcotic volatile falt of vitriol.* Lewis Lemery, eldeft fon to the famous Nicholas Lemery, made many experiments on borax of foda, and difcovered in the year 1728, that the boracic acid, then called *fedative falt,* might be obtained from it by means of pure fulphuric acid, and that the muriatic and the nitric acids likewife feparated it; but fublimation was the procefs which he always ufed. We are indebted to Geoffrey the younger for the firft complete analyfis of borax. In the year 1732, he proved that the boracic acid might be obtained by evaporation and cryftallization; and by examining the refidue which remained after thefe operations, found foda to be one of the principles of borax.

Baron's experiments on this falt, which were laid before the Academy in the years 1745 and 1748, added two important facts to thefe difcoveries: The firft, that vegetable as well as mineral acids decompofed borax of foda: The fecond, that genuine borax may be formed by uniting the boracic acid with foda. The laft of thefe facts proves that the acid is entirely formed in the falt, and that its formation is in no degree owing to the acids employed to decompofe the falt.

The fluoric, and even the carbonic acid though one of the weakeft, appears to be capable of decompofing borate of foda, and feparating the boracic acid. This laft acid unites readily with the borax of commerce; its alkaline bafe requiring, to be fully faturated, rather more of the boracic acid than a quantity equal to the whole weight of the borax. Bergman is even of opinion that this falt is not fully faturated nor properly neutral, and that alkaline properties ftill continue to predominate in

it,

it, till fuch time as it receives this additional quantity of boracic acid. The properties of this neutral falt, when thus faturated, have not as yet been particularly examined.

None of the alkaline neutral falts, whether fulphuric, nitric, or muriatic, acts in any manner on borax of foda·

This falt acquires a reddifh colour when melted with combuftible matters, fuch as charcoal; but we know not yet what alteration it fuffers from thefe matters.

Borax is of great utility in many of the arts. In glafs-making, and the affaying of metals, it is ufed as an excellent flux. It is ufed in foldering metals to make the mixture run, which is defigned for the folder; and it at the fame time foftens the furfaces of the metals to be united, and defends them from being calcined by the. action of the air. It was formerly much ufed in medicine, but has gone quite out of ufe.

Species VIII. *Borate of Potafh.*

WE give the name of *borate of potafh* to the combination of the boracic acid with potafh. It is well known that thefe two faline fubftances readily unite, and that from their union refults a neutral falt, refembling borax of foda. Of this kind is the refidue of nitre of potafh, decompofed by the boracic acid. M. Baumé fays, that this refidue appears in the form of a white half-melted glafs, which when· diffolved in water, affords fmall cryftals. Borate of potafh is therefore fufible, foluble, and fufceptible of cryftallization, and pure acids decompofe it as well as borate of foda. We know nothing more certain of this falt; it fhould be exa-mined

mined in the fame manner as borate of foda. Baron knew the poffibility of producing this falt by a direct combination of the boracic acid with potafh; he has even diftinguifhed it accurately from common borax, or borax with a bafe of foda; but not a word has he faid concerning the peculiar properties of borax of potafh.

Species IX. *Fluate of Soda.*

ACCORDING to the fyftem of nomenclature to which we have conformed from the beginning of this work hitherto, the name *fluate of foda* denotes the combination of the fluoric acid with potafh. This neutral falt has, as yet, undergone but a very flight examination—by Meffrs Scheele and Boullanger. According to thefe two chemifts, it always appears in a gelatinous form, and is never cryftallized. According to Scheele, it becomes, when dried and melted, acrid, cauftic, and gelatinous. He compares it in that ftate to liquor of flints. It appears that fire difengages the fluoric acid; and that the filiceous earth with which it is always impregnated during its preparation, then melts into a foluble glafs with the help of the potafh.

Fluate of potafh diffolves very readily in water. It always retains fo large a proportion of this fluid, that it is impoffible to make it affume a cryftalline form. When it is well faturated, a folution of it produces no alteration on fyrup of violets.

We know not in what manner either filiceous, argillaceous, or barytic earth or magnefia, affects this

According

According to Scheele and Bergman, lime has more affinity than potafh with the fluoric acid. Throw fluate of potafh into lime-water it is inftantly decompofed: lime unites with the fluoric acid, forming an infoluble falt, which takes away the purity of the liquor, and is fluate of lime. We fhall afterwards fee that lime likewife decompofes neutral falts formed of the carbonic acid with fixed alkalis. We have already feen that lime-water precipitates borax of foda; therefore the fluoric is not the only acid which has a greater affinity with that falino-terrene fubftance than with the fixed alkalis.

The concentrated fulphuric acid decompofes fluate of potafh by difengaging its acid; which, according to M. Boullanger, appears in the white vaporous form, and exhales the odour peculiar to the muriatic acid. When this experiment is made in an apparatus proper for diftillation, we obtain the fluoric aeid, juft as we obtain the acids contained in nitre of potafh and muriate of foda, when we decompofe them with the fulphuric acid.

No inquiry has hitherto been made concerning the action of the nitric and the muriatic acids, or of the known neutral falts, on fluate of potafh. This falt is in other refpects little known, and is applied to no ufe.

Species X. *Fluate of Soda.*

THIS is a proper enough denomination for the neutral falt formed by the faturated combination of the fluoric acid with foda. This, like the foregoing falt, has been but very little examined. No body but Meffrs

Scheele

Scheele and Boullanger, has faid any· thing about it;
and they differ in their opinions, as we are about
to fee.

Scheele afferts, that a combination of foda with the
fluoric acid forms a jelly like the preceding falt.
Boullanger, on the contrary, fays, that the combination
affords very fmall, hard, brittle cryftals, of an oblong
fquare figure, a bitter tafte, and fomewhat ftyptic.
This falt decrepitates on burning coals like muriate of
foda; it diffolves in water, but not readily.

Lime-water decompofes this falt as well as fluate of
potafh. The fulphuric difengages the fluoric acid from
this falt with effervefcence, caufing it to rife, like the
muriatic acid, in a white.vapour of a pungent fmell.

From this fhort account of this falt, the reader may
perceive that it is not better known than the laft.

Species XI. *Carbonate of Potafh.*

THE laft two neutral falts which we have to examine,
are combinations of the carbonic acid with fixed al-
kalis.

Thefe fubftances were never before reckoned among
the neutral falts : but we fhall immediately fee that
they are true neutral falts.

What we call *carbonate of Potafh*, is a neutral falt
refulting from a faturated combination of carbonic acid
with potafh. Some modern chemifts call it *mephitic
tartar*, aërated *vegetable alkali*, &c. This faline fub-
ftance was always taken for pure alkali, till Dr Black's
experiments fhowed it to be a neutral falt. Its old
name was *fixed falt of tartar*, becaufe it was obtained

by

by the incineration of tartar of wine. It was confider-
ed as an alkali, becaufe it poffeffes fome of the proper-
ties of alkaline falts. It does indeed convert fyrup of
violets to a green colour; but borax and feveral other
neutral falts poffefs the fame property : befides, it nei-
ther deftroys nor weakens the colour of violets like
potafh. It has an alkaline tafte; but the fame is diftin-
guifhable in borax : only it was diftinguifhed from
alkali of foda by its power of attracting the moifture of
the air with great rapidity, and its not being fufceptible
of cryftallization. When thus moiftened in the air, it
received the name of *oil of tartar per deliquium* *. But
fixed falt of tartar poffeffes thefe two properties only
becaufe it is not a perfect neutral falt. Containing
ftill a certain quantity of potafh not faturated with
carbonic acid, this excefs of alkali renders it delique-
fcent. At prefent, this falt is obtained in a ftate in
which it is very fufceptible of cryftallization, and
attracts no moifture, but rather efflorefces. The
Duke de Chaulnes, who has paid much attention to
this object, prepares this falt by expofing a folution of
potafh, either cauftic or containing a little of the car-
bonic acid, in a place full of carbonic acid, as in
the upper part of a barrel of beer when it is ferment-
ing. The alkali feizes as much of the carbonic acid as
it

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* Bohnius relates, that evaporating oil of tartar flowly, by a mo-
derate heat, he obtained, under a faline pellicle, beautiful cryftals,
which, though expofed to various temperatures, remained fix years un-
altered (*Differt. Phyfico-Chem.* 1656.) M. Montet, a celebrated che-
mift of Montpelier, who was certainly unacquainted with Bohnius's
difcovery, has invented a procefs for cryftallifing this fixed falt of tar-
tar.—F.

it can abforb, and is regularly cryftallifed.   Its cryftals
are quadrangular prifms, terminating in very fhort py-
ramids with four faces.

Carbonate of potafh has an urinous tafte, but much
weaker than that of the cauftic vegetable alkali ; for in
medicine it is given as a difcuffive in dofes of feveral
grains.   This neutral falt is very fubject to alteration
from fire; it melts eafily, and is pretty quickly redu-
ced to an alkali.   If it be diftilled in a retort with a
receiver, and a pneumato-chemical apparatus with mer-
cury fitted to it, the products obtained are, the water
of its cryftallization, and its acid in an aëriform ftate.
The potafh, after this operation, remains in an irregu-
lar mafs, ftill retaining, however, a fmall portion of the
acid, which cannot without the greateft difficulty be
extracted from it by fire.   According to Bergman's
analyfis of it, carbonate of potafh, when faturated with
the acid, and regularly cryftallifed, to which he gives
the name of *aërated vegetable alkali*, contains in the
quintal twenty parts of the acid, forty-eight of pure
alkali, and thirty-two of water.   But it is to be ob-
ferved, that carbonates are more liable than other neu-
tral falts to vary in the quantity of the acid.   Yet, as
this falt never furnifhes regular cryftals but when it is
fully faturated, Bergman's calculation deferves to be
confidered as fufficiently accurate.

Carbonate of potafh, when fully cryftallifed, fuffers
no alteration from air ; its cryftals neither deliquiate
nor efflorefce, but remain tranfparent.   This falt, when
fo pure as to poffefs this property, being of ufe in ma-
ny experiments, it may be proper to let the reader
know that it is prepared in the following manner : By

exposing a lixivium of common potash, very pure and white, and separated from the sulphate of potash which it usually contains, in a shallow dish, in the upper part of a beer barrel ; and the process is the sooner completed, if the potash be continually stirred or poured out of one vessel into another ; and if it be thus kept in contact with the carbonic acid produced by fermentation, till such time as it deposite beautiful crystals of carbonate of potash.

This salt dissolves readily in four parts of cold water, and a rather smaller quantity of warm water will maintain it in solution ; it produces cold as it unites with that fluid. This property which distinguishes neutral from simple salts sufficiently determines the difference between carbonate of potash and pure or caustic potash. It is crystallised by evaporation and cooling conjunctly. When the solution is too much concentrated, it takes the form of an irregular mass,—which often happens in the laboratories.

This salt, as well as potash, serves as a flux to vitrifiable earths ; because fire reduces it to an alkali by expelling the carbonic acid. Besides, when this salt, with a mixture of sand, is violently heated in a crucible, a lively effervescence may be observed at the instant of vitrification ; and that effervescence is owing to the disengagement of the carbonic acid. This fact shows that siliceous earth cannot enter into combination with an alkali saturated with this acid, and that the acid escapes when the vitreous combination takes place. This effervescence attends so invariably the combination of these two substances, that Bergman proposes to try siliceous earth by means of the blow-

pipe, with carbonate of potaſh, as no other earth exhi-
bits the ſame phenomenon when heated with this
ſalt.

Clay does not act at all on carbonate of potaſh ; but
the ſalt reduces that earth to a vitreous frit, though not
quite ſo eaſily as does cauſtic potaſh. Barytes deprives
this ſalt of the carbonic acid.

Lime likewiſe decompoſes it, having a greater affini-
ty than potaſh with the acid. Lime-water poured into
a ſolution of carbonate of potaſh, gives a precipitate of
an almoſt infoluble ſalt, produced by the combination
of lime with the carbonic acid ; and the pure or cauſ-
tic alkali remains diſſolved in the water. In pharmacy,
this proceſs is made uſe of for the preparation of the
lapis cauſticus, which is nothing but fixed vegetable
alkali rendered cauſtic by lime. Modern diſcoveries
have ſhown, that Lemery's proceſs for preparing the
lapis cauſticus, though followed by many pharmaco-
pœiæ, is very defective. It conſiſts in mixing two
pounds of aſhes obtained by the combuſtion of the
huſks of grapes with lees of wine *, with a pound of
quicklime, immerſing the mixture into ſixteen pounds
of water, filtering it, evaporating this lixivium in a
copper veſſel, melting the reſidue in a crucible, and
pouring it out upon a plain ſurface. The product ob-
tained by this operation is merely a dirty alkali not ve-
ry cauſtic, and containing copper.

Bucquet, ſenſible of the diſadvantages of this pro-
ceſs,

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* Theſe aſhes contain a great deal of vegetable alkali or carbonate
and ſulphate of potaſh — F.

cefs, has given one, more tedious and expenfive indeed, but much more certain and advantageous, efpecially for preparing very pure potafh, which is fo neceffary in chemical experiments. Take two pounds of very ftrong quicklime; pour a little water upon it to reduce it to powder; add a pound of fixed falt of tartar, and pour upon it as much water as may be fufficient to form it into a pafte : When this mixture becomes cool, add to it water to the quantity of fixteen pints, and put the whole into a linen cloth lined with paper; about twelve pints of a clear liquor will pafs through this ftrainer, and the remained is to be wafhed with four pints of boiling water to take away all the alkali. This liquor gives no effervefcence with acids : but the beft teft for trying its caufticity is to obferve whether it clouds lime-water; for if it contain the fmalleft portion of carbonic acid, it will infallibly produce that effect. But as, after this firft procefs, it ftill gives a precipitate with lime-water, when very pure alkali is wanted for nice experiments, the lixivium may be treated with two additional pounds of quicklime. It then paffes very clear through the ftrainer, and becomes fo cauftic as not to alter the tranfparency of lime-water. When the alkali is evaporated by fire in the open air, that falt abforbs the carbonic acid contained in the atmofphere; therefore, to obtain it in a dry form, and very pure, we muft evaporate the liquor in a retort. But this very tedious procefs is not neceffary for producing the *lapis caufticus ;* for if alkali be of fuch ftrength as to corrode the furface of the fkin, it is fufficient for the purpofes of that preparation. But as dry folid potafh, in a ftate of high purity, is necef-

fary

fáry in many experiments, I muft here obferve, that
the cauftic alkaline lixivium muft be evaporated.
in clofe veffels, and that the fire muft be very cauti-
oufly managed, becaufe the evaporation is attend-
ed with confiderable difficulty, in regard to the den-
fity which the liquor affumes towards the end of the
procefs. The fixed alkali is very white, and does not
effervefce with acids, nor deftroy the purity of lime-
water.

Magnefia does not act on carbonate of potafh; for
the carbonic acid has a greater affinity with fixed
vegetable alkali than with that falino-terrene fub-
ftance.

The fulphuric, the nitric, the muriatic, and the
fluoric acids, decompofe carbonate of potafh by
combining with the fixed alkali, and feparating the
carbonic acid with effervefcence. The acid may be
collected under water or mercury. It is diftinguifh-
able by the four following characteriftics: it is
more ponderous than air; it extinguifhes lights;
reddens tincture of turnfol; and precipitates lime-
water.

The boracic acid feems incapable of feparating the
acid from carbonate of potafh cold; but when hot, it
effects it with great eafe.

The neutral falts which we have examined, neither
fuffer any alteration from carbonate of potafh, nor pro-
duce any fuch effect upon it.

This falt abounds in nature. It is often found in ve-
getables, completely formed, and is conftantly ob-
tained by the incineration of thefe organic bodies; as
we fhall have occafion to fhow when we come to fpeak

of

of the vegetable kingdom. Burnt tartar affords it in the greateft abundance. It is alfo prepared by the de-tonation of nitre of potafh.

Carbonate of potafh is much ufed in the arts. In medicine, it is adminiftered as an aperient and difcuf-five, in obftructions of the mefentery and the urinary paffages. It is always given in fmall dofes, and along with fome fubftance of efficacy to moderate its ac-tion.

Species XII. *Carbonate of Soda.*

THIS falt, like the foregoing, was formerly thought an alkali. It is, however, a combination of the car-bonic acid with mineral alkali. This feems to be the falt which the ancients called *natrum.* It is ufually called *falt of foda,* becaufe it may be obtained pure and regularly cryftallifed by evaporating a lixivium of common foda. Marine alkali is likewife diftinguifh-ed from vegetable fixed alkali, by its being fufceptible of cryftallifation and efflorefcence, which is owing to its being completely faturated with carbonic acid in its ordinary ftate.

Carbonate of foda has an alkaline tafte; it commu-nicates a green colour to fyrup of violets, but does not like cauftic foda, finally alter its colour. Its tafte is urinous, but not burning, and much weaker than that of pure marine alkali.

This falt is naturally purer than carbonate of potafh, and has been long known to be fufceptible of cryftal-lifation; a property which may be confidered as form-ing a general diftinction between neutral and fimple

falts. Its cryftallifed form is owing to its containng almoft always the quantity of carbonic acid neceffary to its faturation and cryftallifation.

This falt, when haftily cryftallifed, exhibits rhomboidal plates, difpofed obliquely over one another, like tiles on the roof of a houfe. When flowly cryftallifed, it affumes the form of rhomboidal octohædrons, with pyramids truncated near the bafe, or folid decahædrons, with two acute and two obtufe angles.

This falt generally melts eafier than carbonate of potafh; for which reafon it is ufed in preference to it in the glafs-houfes. It lofes moft part of its acid by heat but ftill retains a little. Bergman has found, by an exact analyfis, that an hundred parts of carbonate of foda, which he calls *aërated mineral alkali*, contain fixteen parts of the acid, twenty of pure alkali, and fixty-four of water:—fo that more of the acid is requifite to faturate foda than to faturate potafh; and the cryftals of the former retain juft twice as much water as thofe of the latter. It is to this extraordinary quantity of water that carbonate of foda owes its cryftallifing with fuch facility and regularity, as well as its property of efflorefcing.

Carbonate of foda is more foluble than carbonate of potafh. It diffolves in two parts of cold or one of boiling water. It cryftallifes by cooling, but gives much more regular cryftals by flow evaporation.

When this falt is expofed to the air, it crumbles down very readily into duft; for the air deprives it of the water of its cryftallifation: But it is not altered by this efflorefence; for we can reftore it to its primary form by folution in water.

It

It contributes greatly to the fufion of vitrifiable earths, and forms with them a glafs lefs liable to alteration than that which is in part compofed of carbonate of potafh, to which it is for this reafon preferred in the glafs-houfes. It has been obferved, that when fand unites with this falt, it expels the acid, which efcapes with a very obfervable effervefcence, agreeably to what we have remarked of carbonate of potafh. It has no more influence on clay than the laft falt.

Barytes, as well as quicklime and limewater, decompofes carbonate of foda in the fame manner as carbonate of potafh, and feparates the pure cauftic mineral alkali. A folution of this falt poured into limewater produces a precipitate; an effect which is never produced by cauftic foda. When pure cauftic foda is wanted for nice chemical experiments, recourfe muft be had to the fame procefs which we defcribed above for preparing the *lapis caufticus.*

Carbonate of foda, as well as carbonate of potafh, may be decompofed by the fulphuric, the nitric, and the muriatic acids, &c. The carbonic acid may be obtained from it by collecting it into a glafs filled with water or mercury.

In Egypt, this falt is found entirely formed at the furface of the earth, as well as in feveral other places. It is likewife found in the afhes of fea-weeds, but not completely faturated with the acid. To render it more perfectly neutral, it muft be directly combined with the cretaceous acid, either by fhaking it over fome liquor in a ftate of fermentation, or by receiving into a folution of it a portion of the carbonic acid, feparated from

from chalk by the fulphuric acid. It may be alfo pro-
duced by wetting the fides of a veffel with a folution
of foda, and then pouring into the veffel a quantity.
of carbonic acid : the mouth of this veffel is then to
be covered with a wet bladder; and at the end of a
few hours, the combination is found to be effected,—
for the bladder is emptied by the abforption of the
carbonic acid, and the fides of the veffel are covered
with the falt in regular cryftals.

Carbonate of foda may be applied to the fame pur-
pofes with carbonate of potafh. It is much more ufed
in foap and glafs manufactories, &c. &c. We fhould
therefore endeavour to procure it in greater quantities,
and to extract it in the great way from muriate of fo-
da. We have feen that litharge, which fome chemifts
pretend to be adequate to this effect, does not proper-
ly decompofe that falt. We have alfo taken notice of
Scheele's having difcovered a more entire decompofi-
tion of muriate of foda, effected by quicklime and iron,
with the help of atmofpheric air, and the carbonic
acid which it contains. We fee that a greater propor-
tion of this acid than what ufually exifts in the atmof-
phere, is requifite to promote this decompofition, by
exerting its attractive force on the foda.

END OF VOL. I.